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HELMINTH PARASITES OF THE SHORT-TAILED SHREW IN CENTRAL OHIO

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A number of helminth parasites have been reported for the short-tailed shrew, *Blarina brevicauda*. These reports are scattered, and there has been no attempt to bring this literature together to aid in the identification of the parasites of this host.

Ninety-three short-tailed shrews from central Ohio have been examined for helminth parasites since 1950. Eighty-three of these shrews were collected in Franklin County; six were collected in Hocking County; two were collected in Delaware County; and two were collected in Licking County. Helminth parasites were recovered from seventy-eight (83.9%) of the shrews.

Six species of tapeworms, four species of flukes, eight species of roundworms, and one acanthocephalan were recovered in this study. Several of these parasites represent new host records, and one tapeworm and one fluke appear to be new species. In both of the latter cases, however, the specimens were not in a condition favorable for detailed study. Only one helminth which has been reported for *Blarina brevicauda* was not recovered in this study, i. e., *Oochoristica pennsylvanica* Chandler and Melvin, 1951.

List of Parasites

Cestoda
- Hymenolepididae
  - *Hymenolepis anthocephalus* Van Gundy, 1935
  - *H. blarinae* Rausch and Kuns, 1950
  - *Hymenolepis* sp.
  - *Pseudodiorchis reynoldsi* (Jones, 1944)
  - *Protogynella blarinae* Jones, 1943
  - *P. pauciova* Oswald, 1955

Trematoda
- Brachylaimatidae
  - *Entosiphonus thompsoni* Sinitsin, 1931
  - *Brachylaima rhomboideus* (Sinitsin, 1931)
  - *Panopistus pricei* Sinitsin, 1931
- Troglotrematidae (?)
  - Undetermined fluke

Nematoda
- Strongyloididae
  - *Parastrongyloides winchesi* Morgan, 1928
- Trichostrongylidae
  - *Longistriata depressa* (Dujardin, 1845)
- Metastrongylidae
  - *Angiostrongylus blarini* Ogren, 1954
- Ascarididae
  - *Porrocaecum americanum* Schwartz, 1925 (larva)
  - *P. encapsulatum* Schwartz, 1925 (larva)
  - *P. ensicaudatum* (Zeder, 1800) (larva)
- Physalopteridae
  - *Physaloptera limbata* Leidy, 1856
- Trichuridae
  - *Capillaria blarinae* Ogren, 1953

Acanthocephala
- Polymorphidae
  - *Centrorhynchus conspectus* Van Cleave and Pratt, 1940 (cystacanth)

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Cestoda

Hymenolepis anthocephalus *Van Gundy, 1935*

This tapeworm was originally described from the short-tailed shrew in Michigan and has been reported subsequently for the same host in Ohio, Michigan, and Wisconsin by Rausch and Kuns (1950). Skrjabin and Matevosian (1948) erected the genus *Cryptocotylepis* with *C. anthocephalus* (Van Gundy) as the type and only species. This genus is differentiated from *Hymenolepis* entirely on the basis of scolex characters. Since the anatomy of the proglottid of *H. anthocephalus* is typical of other members of the genus *Hymenolepis*, there would appear to be little advantage in placing this species in a separate genus.

H. anthocephalus was encountered in the intestine of 29 shrews from Franklin Co., 2 from Delaware Co., 1 from Licking Co., and 1 from Hocking Co. Each host harbored from 1 to 15 worms.

Hymenolepis blarinae *Rausch and Kuns, 1950*

The species was originally described from *Blarina brevicauda* in Wisconsin. One shrew collected in Hocking County harbored 5 specimens of this species.

Hymenolepis *sp.*

A single, rather badly decomposed tapeworm which appeared to belong to the genus *Hymenolepis* was obtained from a shrew collected in Franklin County. The scolex of this specimen was armed with ten hooks 76 to 82 μ long (fig. 1). On the basis of the size, number, and shape of these hooks, this specimen appears to belong to an undescribed species. However, suitable specimens must be collected before this species can be thoroughly studied and named.

Pseudodiorchis reynoldsi (*Jones, 1944*)

This species was originally placed in the genus *Diorchis* by Jones (1944) who obtained it from *Blarina brevicauda* in Virginia. Skrjabin and Matevosian (1948) erected the genus *Pseudodiorchis* and designated *P. reynoldsi* (Jones) as the type. *P. reynoldsi* has recently been redescribed by Oswald (1957) from specimens collected in Ohio.

P. reynoldsi has been collected in Franklin, Hocking, and Delaware Counties in 17, 1, and 1 shrews, respectively. Each infected host harbored from 1 to 47 worms.

Protogynella *spp.*

The genus *Protogynella* was erected by Jones (1943) for a minute tapeworm, *P. blarinae*, from *Blarina brevicauda* collected in Virginia. An additional species, *P. pauciova*, was described by Oswald (1955) from the short-tailed shrew in Ohio. *P. blarinae* has also been reported for *Blarina brevicauda* in Wisconsin by Rausch and Kuns (1950) and from *Sorex vagrans* in Oregon by Locker and Rausch (1952). According to Oswald (1955), *Protogynella* occuring in *Sorex* spp. differs from both *P. blarinae* and *P. pauciova*, and probably represents one or two additional species.

P. blarinae was encountered in two short-tailed shrews from Hocking Co., the shrews harboring 43 and 260 worms, respectively. Twenty-nine specimens of *P. pauciova* were obtained from a shrew in Franklin Co., and 295 specimens were obtained from a shrew in Hocking Co. In the latter case, the specimens differed from the original description of *P. pauciova* in that there were occasionally three eggs per proglottid rather than two as reported originally. An additional shrew from Hocking County harbored *Protogynella*, but these specimens were so badly decomposed that they could not be identified to species.

Oochoristica pennsylvanica *Chandler and Melvin, 1951*

This species, which was reported for *Blarina brevicauda* in Pennsylvania, is the only tapeworm from the short-tailed shrew which was not encountered in this study. However, it is reasonable to expect it to occur in Ohio.

Trematoda

Entosiphonus thompsoni *Sinitsin, 1931*

E. thompsoni was originally described from *Blarina brevicauda* in Virginia and Maryland.

It was found in Franklin, Delaware, Hocking, and Licking Counties in 30, 2, 2, and 2 shrews, respectively. Each shrew harbored from 1 to 17 flukes in the small intestine.

Panopistus pricei *Sinitsin, 1931*

The fluke was described also from the short-tailed shrew in Virginia. In the present study, it was found in 9 shrews from Franklin Co., 1 shrew from Delaware Co., and 1 shrew from Licking Co. It was found in the large intestine; from 1 to 9 specimens were obtained from each host.

Brachylaima rhomboideus (*Sinitsin, 1931*) *Villella, 1953*

Mason (1953) described a fluke from *Blarina brevicauda* in Tennessee which he named *Brachylaima dolichodirus*. However, Villella (1953) found that the adult of *Ectosiphonus rhomboideus*, which Sinitsin (1931) had described from rediae, cercariae, and metacercariae occurring in *Ventridens ligera* in the vicinity of Washington, D. C., was identical to Mason's *B. dolichodirus*. Villella retained this species in the genus *Brachylaima*, but *B. dolichodirus* of Mason becomes a synonym of *E. rhombiodeus* of Sinitsin.

B. rhomboideus was found in 6 shrews from Franklin Co., 2 from Delaware Co., and 1 from Licking Co. It was taken most frequently in the duodenum, but specimens were occasionally found in the stomach. From 1 to 8 specimens were found in each host.

Sinitsin (1931) described *Ectosiphonus ovatus* from *Blarina brevicauda* in Minnesota, and Odlaug (1952) described *Brachylaima condylura* from a star-nosed mole, *Condylura cristata*, also in Minnesota. Since the descriptions and illustrations of these two species were similar to *B. rhomboideus* in several respects, a direct comparison of these three species appeared to be desirable. Mr. Allen McIntosh, Agricultural Research Center, Beltsville, Maryland kindly furnished the type specimens of *B. condylura* and *E. ovatus*, together with three additional specimens of the latter species. Dr. T. O. Odlaug, University of Minnesota, Duluth Branch, very kindly furnished two paratype specimens of *B. condylura*.

A comparison of the type specimens of *B. condylura* and *E. ovatus* with my specimens of *B. rhomboideus* revealed no differences which could not be accounted for when the different degrees of contraction of the specimens were taken into consideration. Odlaug states that the ovary of *B. condylura* is on the right side of the body, although in his illustration the ovary would appear to be on the left side of the body. A comparison of his illustration with the type specimen indicated that the drawing should be labeled as a dorsal view rather than a ventral view. In addition, the anterior end of the type specimen is somewhat contracted and folded, giving the impression that the distance between the oral sucker and the acetabulum is relatively short. In the two paratype specimens of *B. condylura*, the neck region is relaxed and relatively long.

The specimens of *Ectosiphonus ovatus*, which consist of three whole mounts and one sectioned specimen, are all extremely contracted and are very poor taxonomic material. In Sinitsin's figure 37 which illustrates a whole specimen of *E. ovatus*, the impression of a ventral view is obtained. However, a comparison of this figure with the type specimen showed that this drawing is also a dorsal view.

In all three groups of specimens, the size of the body and the organs overlap; the ovary is located to the right of the testis; the genital pore is located just anterior to the anterior testis; the vitellaria extend from the posterior testis to a point midway between the acetabulum and the anterior testis; a loop of the uterus extends to the left between the ovary and the anterior testis; and the vitelline reservoir is located to the left of the ovary with the right vitelline duct passing between the ovary and the posterior testis. The location of the uterus in relation to the acetabulum appears to be variable; in some of my specimens it passes to the left of the acetabulum, but occasionally it passes to the right or one branch may pass to the left while the other passes to the right.

Since Sinitsin erected the genus *Ectosiphonus* for *E. rhomboideus* and *E. ovatus* and since these two names apparently apply to the same species of fluke, there is some question as to which of these specific names has priority. Although Sinitsin did not designate directly the type species for the genus *Ectosiphonus*, the description of *E. rhomboideus* is the first species description following the generic diagnosis, and it is, therefore, the implied type of the genus and has priority over *ovatus*. Since Villella, Odlaug, and Mason have rejected either directly or in-

directly Sinitsin's genus *Ectosiphonus*, this genus must now be considered a synonym of *Brachylaima*. Therefore, the correct name for this fluke is *Brachylaima rhomboideus* (Sinitsin, 1931) Villella, 1953, and the synonyms would include *Ectosiphonus ovatus*, *Brachylaima condylura*, and *B. dolichodirus*.

Unidentified Fluke

Two specimens of an unidentified fluke were obtained from the large intestine of a short-tailed shrew collected in Franklin County. The extensive and heavily developed vitellaria and the uterus obscured much of the internal anatomy. Therefore, an outline drawing was made from a whole mount after which the flukes were sectioned, and the internal anatomy was reconstructed from these serial sections. A brief description of this fluke follows.

Unidentified Fluke

Figure 2

Diagnosis: Body pyriform, 2.04 mm long and 0.524 mm wide just anterior to acetabulum. Cuticle without spines. Oral sucker 235 to 248 μ in diameter, oral opening subventral. A small, poorly developed pharynx present, followed by a larger, thin-walled esophagus. Esophagus opens into the intestinal ceca ventrally; ceca very distinct, extending to the posterior end of worm. Acetabulum 221 to 228 μ in diameter, located posterior to mid-point of body. Vitellaria extensive, composed of closely packed follicles 50 to 70 μ in diameter. Vitellaria enveloping the body from just behind oral sucker to tip of tail, except for the region on the ventral surface between the acetabulum and cirrus sac. Cirrus sac located to right of mid-line, anterior to acetabulum and ovary. Cirrus protruded in both specimens; an internal seminal vesicle present. Two testes present, one on the left just anterior to acetabulum and one directly dorsal to acetabulum. Testes 148 to 175 μ in diameter. Ovary located on the right, just anterior to acetabulum, about 117 μ in diameter. Uterus extending between the intestinal ceca from middle of acetabulum to a point slightly anterior to cirrus sac. Uterus passes ventral to ovary and dorsal to both testes. Eggs 70 to 76 μ long and 30 to 33 μ wide, provided with an operculum. Excretory bladder tubular, extending to middle of acetabulum. Excretory pore subterminal.

It is impossible from the material at hand to assign this fluke to any known genus. It appears to have some features in common with the small, intestinal flukes of the family Troglotrematidae although the location of the genital pore and the arrangement of the ovary and testes would seem to exclude this species from the family. Therefore, the status of this fluke must be left unsettled until additional material has been studied.

Nematoda

Parastrongyloides winchesi *Morgan, 1928*

This species was described by Morgan (1928) from the intestine of the mole, *Talpa europaea*, in England. He also recorded it from a "shrew" in the same area.

P. winchesi was found in the intestine of seven short-tailed shrews collected in Franklin County. It is possible that the incidence of infection is much greater since this worm is small and could have been overlooked in a number of instances. Morgan noted that the females of this species fell into two groups. In one group, the females had an average length of 1.46 mm and contained only a few eggs, usually less than ten. Females in the second group had an average length of 2.2 mm and contained a larger number of eggs. This same condition was found in the specimens from *Blarina*, females of both types occurring in the same host.

The occurrence of *P. winchesi* in *Blarina brevicauda* is apparently a new host record and is the first record of this species in North America.

Longistriata depressa (*Dujardin, 1845*)

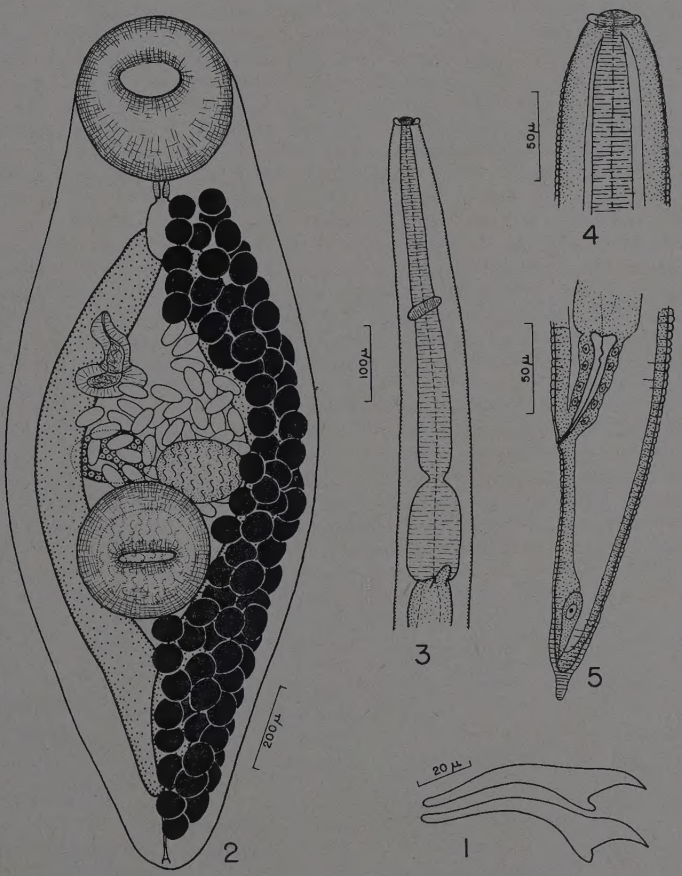
Longistriata depressa has been reported for a number of European insectivores, including *Sorex araneus*, *Crocidura leucodon*, and *C. russula*. Dikmans (1946) described a similar species, *Longistriata caudabullata*, from *Blarina brevicauda* in Maryland. Thomas (1953) considered Dikmans' species to be a synonym of *L. depressa*.

L. depressa was found in the intestine of ten shrews from Franklin County and two shrews

from Hocking County. Because of the small size of this parasite, it could have been overlooked in a number of hosts.

Angiostrongylus blarini *Ogren, 1954*

This species, originally described from cysts in the lungs of *Blarina brevicauda* from Illinois, was found in five shrews from Franklin County. Each infected shrew had one or two cysts in the lungs. This parasite may be more prevalent than indicated since the lungs of a number of shrews were not examined.



Figures made with the aid of a camera lucida.

1. Rostellar hooks of *Hymenolepis* sp.
2. Unidentified fluke. Internal organs reconstructed from serial sections; vitellaria omitted on left side of drawing.
3. *Porrocaecum ensicaudatum*, anterior end of third-stage larva showing ventriculus and intestinal caecum.
4. *P. ensicaudatum*, head of third-stage larva.
5. *P. ensicaudatum*, tail of third-stage larva.

Porrocaecum *spp.*

Third-stage larvae of three species of the genus *Porrocaecum* were encountered in this study. Two of these, *P. encapsulatum* and *P. americanum*, occur in cysts. The third species, which has been identified tentatively as *P. ensicaudatum*, was found free in the intestine.

Schwartz (1925) described *P. encapsulatum* from subcutaneous cysts in *Blarina brevicauda* and *P. americanum* from subcutaneous cysts in *Scalopus aquaticus*. Chandler and Melvin (1951) found *P. encapsulatum* in cysts located both subcutaneously and in the mesenteries of *B. brevicauda* and *Parascalops breweri*. *P. americanum* was found in cysts attached to the small intestine of *B. brevicauda*, on the outer wall of the stomach in *Sorex* (*fumaris?*), and in the mesenteries of *Parascalops breweri*. It would appear from these reports that these larvae can be accomodated by a number of species of Insectivora, and that the tissue site is not very specific.

In the present study, *P. encapsulatum* was found in subcutaneous cysts in twelve shrews collected in Franklin County. Each shrew harbored from one to eight larvae. *P. americanum* was found in twenty shrews from Franklin County and in one from Hocking County. In twelve shrews the cysts were found in the mesenteries; in three shrews the cysts were attached to the stomach; and in six shrews the cysts were found in both the mesenteries and on the stomach wall. The cysts occurring in the mesenteries were more or less free in a fingerlike tube of mesentery located at the junction of the stomach and intestine. The cysts on the stomach wall were at times firmly imbedded under the serosa and at other times they were attached to the stomach wall by a peduncle of connective tissue. Each infected host harbored from one to nine larvae.

Schwartz (1925) suggested that *P. americanum* and *P. encapsulatum* probably occur as adults in birds of prey. He also pointed out the similarity between *P. americanum* and *Ascaris incisa* (Zeder, 1803) which is found encysted in European insectivores. Chandler and Melvin (1951) also suggest that *P. americanum* may be identical to *Ascaris incisa*.

Leukart (1876) suggested that *Ascaris incisa* was the larval stage of *Porrocaecum depressum* which is found as an adult in various birds of prey. This suggestion has become generally accepted in parasitological literature. Although the larvae in European insectivores have been referred to commonly as "*Ascaris incisa*," Osche (1955) points out that the correct name for this larva is actually *Porrocaecum talpae* (Schrank, 1788). Osche also determined by feeding experiments that *P. talpae* is actually the larva of *P. angusticolle* (Molin, 1860) rather than the larva of *P. depressum*. Unfortunately, the law of priority requires that *P. angusticolle* (Molin, 1860) become a synonym of *P. talpae* (Schrank, 1788).

My specimens of *P. americanum* compare favorably with the description of *P. talpae* presented by Osche, although my specimens seem to be somewhat smaller (3.79 to 8.72 mm in total length). *P. talpae*=*P. angusticolle* is known to occur in North America; it has been reported for six species of hawks by Morgan and Schiller (1950). Although a morphological comparison of larval *P. talpae* with *P. americanum* would tend to indicate that they are identical, feeding trials should be undertaken to establish this identity definitely.

The author has made several unsuccessful attempts to determine the adults of the larval *Porrocaecum* encysted in *Blarina*. Six week old chicks were employed in the first experiment. One chick was fed eight encysted *P. americanum*. It was negative when examined after eleven days. A second chick was fed two cysts containing *P. encapsulatum*. This chick was also negative when examined after twenty-three days. Newly-hatched chicks were employed in a second experiment. One chick was fed four and a second chick was fed seven encysted *P. encapsulatum*. These chicks were negative when examined after four and seven days, respectively. In the third experiment, two screech owls (*Otus asio*) were fed seven and eight cysts containing *P. encapsulatum*. These owls were examined at intervals of seventeen and forty days, respectively, and were negative. Two additional owls were fed five and six cysts containing *P. americanum*. These owls were negative when examined after intervals of eighty-five and sixty-four days, respectively. The failure to establish an infection in these owls is not conclusive. These owls had been maintained in the laboratory for over two years before attempts were made to infect them, and they could have been refractive to infection.

In addition to the larvae encysted in the shrews, ten *Blarina* from Franklin County harbored from one to four larval *Porrocaecum* in the intestine. Osche (1955) found third-stage larvae which he identified as *P. ensicaudatum* in the circulatory system of the European earthworm

(*Lumbricus herculeus*). The larvae from the intestine of *Blarina* compare very favorably with the description which Osche gives for *P. ensicaudatum* and is tentatively identified as this species. The adult of *P. ensicaudatum* occurs in a number of passeriform birds, including the starling and the robin. The presence of the larvae in the intestine of *Blarina* must be considered an accidental infection which is obtained when the shrew eats an infected earthworm. Following is a brief description of the larvae from the shrew.

Porrocaecum ensicaudatum (*Zeder, 1800*)

Figures 3, 4 and 5

Diagnosis: Third-stage larva. Total length 3.60 to 4.63 mm; maximum diameter 97 to 148 μ. Cuticle with conspicuous transverse striations. Esophagus 379 to 462 μ long; ventriculus 106 to 129 μ long and 55 to 70 μ in diameter. Intestinal caecum very short, 12 to 47 μ long, usually located dorsolaterally on the left side of the larva. Nerve ring 198 to 246 μ from anterior end. Tail 117 to 153 μ long. A brown pigment, probably derived from hemoglobin, is present in the lumen of the intestine, the cells of the intestine, and in the dorsal, ventral, and lateral chords. The region from the ventriculus to the anterior end of the larva and from the rectum to the tip of the tail is free of pigment.

Physaloptera limbata *Leidy, 1856*

This species was originally described by Leidy (1851) under the name of *Spiroptera scalopis canadensis* from a mole (*Scalopus aquaticus*). Later, Leidy (1856) renamed this parasite *Physaloptera limbata*. Morgan (1946) redescribed this species from specimens obtained from *Scalopus a. aquaticus*, *S. aquaticus machrinus*, *S. aquaticus machrinoides*, and *Parascalops breweri*.

This worm was encountered in one shrew from Franklin County. Four specimens were found in the stomach.

Capillaria blarinae *Ogren, 1953*

C. blarinae was described by Ogren (1953) from the esophagus of *Blarina brevicauda* in Illinois. In the present study, it was found in the esophagus of fourteen shrews collected in Franklin County. This incidence is probably lower than is actually the case since the esophagus was not examined in a number of hosts. The exact number of worms per host was not determined, but they were quite numerous in some shrews.

Acanthocephala

Centrorhynchus conspectus *Van Cleave and Pratt, 1940*

A single, juvenile, male acanthocephalan was recovered from a cyst in the mesenteries of a short-tailed shrew collected in Hocking County. This specimen was identified as belonging to the genus *Centrorhynchus*. There are only three recognized species of *Centrorhynchus* in North American hosts. These include *C. californicus* Millzner, 1924, a larval form encysted in *Hyla regilla*; *C. spinosus* (Kaiser, 1893) from the egret, *Herodias egretta*; and *C. conspectus* Van Cleave and Pratt, 1940 from the barred owl, *Strix v. varia*.

The juvenile from the shrew was tentatively identified as *C. conspectus*. According to the original description of this species, the proboscis is armed with 26 to 28 (rarely 30 or 32) longitudinal rows of hooks with 17 to 18 (rarely 16 or 19) hooks in each row. In each row of hooks, the anterior 4 or 5 hooks are large, and the posterior 12 to 15 hooks are small. In the specimen from the shrew, there were 29 longitudinal rows of hooks with 13 small and 4 or possibly 5 large hooks in each row. The proboscis was not entirely everted which made it difficult to determine exactly the number of large hooks per row. Nevertheless, the number and arrangement of the hooks fall within the range given for *C. conspectus*.

There is apparently only one record of an acanthocephalan occurring in North American shrews. Van Cleave (1953) lists a juvenile specimen of *Centrorhynchus* sp. from the intestine of *Sorex palustris navigator* from Oregon. Cystacanths of apparently the same species were found in several species of Amphibia in the same area which suggested that the specimen found in the shrew as an accidental infection resulting from eating an infected amphibian.

DISCUSSION

The large number of species of helminths which parasitize *Blarina brevicauda* and the high percent infection of this host can probably be correlated directly with the food habits of this animal. Hamilton (1930) analyzed the stomach contents of 244 short-tailed shrews. He gives the following figures based upon bulk: insects, 47.8 percent; plant material, 11.4 percent; annelids, 7.2 percent; sowbugs, 6.7 percent; snails and slugs, 5.4 percent; vertebrates, 4.1 percent; centipedes, 3.8 percent; arachnids, 2.0 percent; millipedes, 1.7 percent; undetermined, 5.2 percent; inorganic matter, 2.3 percent; and empty, 1.7 percent. Since a large number of helminths utilize an intermediate host such as an insect, earthworm, or mollusk in their life cycle, it is apparent from the data above that shrews might commonly ingest the intermediate stages of helminths with their food.

No life cycles are known for the cestodes which parasitize *Blarina*, although Van Gundy (1935) found very immature specimens of *Hymenolepis anthocephalus* associated with larval elaterids in the stomach of a shrew. The hymenolepidids very frequently utilize an arthropod as an intermediate host which probably explains the large number of species of hymenolepidids which are found in insectivorous animals such as shrews. Insects are utilized in all of the life cycles which are known for the genus *Oochoristica*, and we can assume that the life cycle of *O. pennsylvanica* is similar.

There are a number of studies on the life histories of the brachylaimatid flukes occurring in *Blarina* (Sinitsin, 1931; Krull, 1935; Reynolds, 1938; and Villella, 1953a, 1953b, 1954). The metacercariae of these flukes occur in a number of land pulmonates, and consequently *Blarina* would pick up the infection directly by eating these infected mollusks.

A number of the nematodes which parasitize *Blarina* can be accounted for directly by considering the feeding habits of the shrew. Life cycle studies on these nematode parasites are sparse, but by considering life cycle studies of related species, a general idea of a number of these cycles can be obtained.

Ogren (1954) found third-stage larvae of *Angiostrongylus blarini* in the foot muscle and epithelial folds of the slug, *Philomycus carolinianus*. As was pointed out earlier in this paper, the third-stage larvae of *Porrocaecum ensicaudatum* which are found in the intestine of *Blarina* are probably accidental infections obtained by eating infected earthworms. The method by which *Blarina* becomes infected with *P. encapsulatum* and *P. americanum* is not known. However, it is possible that the eggs are picked up first by some invertebrate such as an earthworm and that the shrew becomes infected by ingesting the eggs or very early developmental stages in the invertebrate animal.

Physaloptera limbata is probably obtained directly from an infected arthropod intermediate host since such a host is utilized in all of the life cycles which are known in this genus.

The method by which infections of *Capillaria blarinae* are acquired is not known although some species in this genus require earthworms as intermediate hosts (Hyman, 1951).

The life cycle of *Longistriata depressa* is not known. According to the treatment of the trichostrongyloides in Hyman (1951), infections in this group come about either by direct skin penetration or by ingesting the infective larvae together with food.

Morgan (1928) pointed out the morphological similarity of *Parastrongyloides winchesi* and members of the genus *Strongyloides*. In the latter group, the life cycle consists of an alternation between a free-living generation which reproduces sexually and a parasitic generation which consists entirely of parthenogenetic females. The infection of the definitive host is accomplished by direct skin penetration by infective larvae. *Parastrongyloides winchesi* differs from *Strongy-*

loides in that both males and females are present in the parasitic generation. Whether a free-living generation occurs and whether infection of the shrew is accomplished directly by skin penetration is not known.

Although the life cycle of *Centrorhynchus conspectus* is not known, the cystacanth of this species which was found in one shrew suggests that *Blarina* may serve as the second intermediate host of this acanthocephalan. Van Cleave and Pratt (1940) state that an arthropod undoubtedly acts as the first intermediate host of this species, but they suggested that an amphibian probably serves as the second intermediate host. From a preditor-prey relationship, however, *Blarina* would appear to represent a suitable second intermediate host. The shrew could easily become infected by eating the arthropod intermediate host, and *Blarina* in turn forms a frequent article in the diet of owls.

We may conclude from this discussion that the large and varied helminth fauna of the shrew can be attributed largely to the feeding habits of this animal. With the possible exception of several of the parasites discussed, the helminths occurring in the shrew require an intermediate host, and these hosts are frequently preyed upon by the shrew.

SUMMARY

Six species of tapeworms, four species of flukes, eight species of roundworms, and one acanthocephalan were recovered from ninety-three short-tailed shrews examined from central Ohio. One fluke and one tapeworm appear to represent new species, but in both cases the material did not permit a detailed study of these worms.

Ectosiphonus ovatus Sinitsin, 1931 and *Brachylaima condylura* Odlaug, 1952 were found to be synonyms of *Brachylaima rhomboideus* (Sinitsin, 1931). The finding of *Parastrongyloides winchesi* represents a new host and distribution record. The third-stage larva of *Porrocaecum ensicaudatum* was reported for the first time from the intestine of *Blarina*, but this is apparently an accidental infection. A cystacanth of *Centrorhynchus conspectus* was reported for the first time from *Blarina*.

The helminth fauna of the shrew is discussed from the standpoint of the life cycles of the parasites and the feeding habits of the shrew.

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Principles of Field Biology and Ecology. *Allen H. Benton* and *Wm. E. Werner, Jr.* McGraw-Hill Book Co., N. Y. vii+341 pp. $6.50.

Most of the early biologists were field workers, and they based their studies on extensive collections of data made in the field. Certain laboratory aspects of biology were emphasized during the latter part of the last century and the early part of this century, and only recently has there been revived interest in field work. The recent rise of ecology, the increased need for conservation of natural resources, and the upsurge of popular interest in nature study have sent amateurs and professionals into the field in large numbers. This book is a text for use by college students who are just starting to study field biology or ecology, and it is designed to stimulate interest in nature while providing knowledge of the principles and practices used in making field studies.

Chapters are devoted to a brief history of field biology in America, the principles of taxonomy and ecology, plant successions on land and in water, economic field biology, the principles of population study and of behavior study, and the use of biological literature. There is a glossary, an appendix full of useful aids for the student, and a good index.

THOMAS H. LANGLOIS

DAILY WEATHER MAPS AS ILLUSTRATIONS OF WEATHER TYPES

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Within the last fifteen years climatologists have grown increasingly aware of the significance of the circulation of the air at middle and high levels to the patterns of surface weather phenomena. The first awareness of the existence of the Jet Stream during the early 1940's opened the door to many discoveries of the relation of upper air phenomena to surface expression.

It is the purpose of this paper to point out a limited number of such relationships which are clearly demonstrable on the United States Government's *Daily Weather Map*. On the *Daily Weather Map* an upper air chart, titled the "500 Millibar Constant Pressure Chart" shows, by means of contour lines, the height in feet of the pressure level surface for 500 mbar of air pressure, determined by radiosonde observations. Air circulation is most active where these contour lines are closest together; hence the Jet Stream is easily identified by noting those areas of contour line concentration.

Jet Stream flow is most significant in concentrating middle and upper air flow; in directing the movement of surface pressure systems; in establishing areas of convergence; and, under favorable conditions, in establishing areas of precipitation.

The succeeding weather map examples will point out the more important relationships between middle and upper air Jet Stream flow and surface weather phenomena.

Arctic Outbreak (*Figure 1*)

January 18, 1957.—The 500 mbar constant pressure chart is dominated by a large trough over the eastern half of the United States. Jet Stream flow is favorable for the rapid movement southward to the Gulf of Mexico of continental Arctic air, produced in northwestern Canada and Alaska. The map of North America in the upper left shows a ridge of high pressure at the surface extending from Alaska south to northeastern Mexico, a distance of 2500 mi. Rapid feeding southward of fresh Arctic air carried the 32° isotherm south of the Rio Grande on the border between Texas and Mexico, to the mouth of the Mississippi (New Orleans had a reading of 28°) and into northern Florida. Zero readings were carried as far south as the Ohio valley, and as far east as southern New England. A new state record low of −55° was established in New York state, and Boston had the second coldest January day in its history.

Diverging and Converging Jet Stream Flow (*Figure 2*)

January 29, 1957.—The 500 mbar constant pressure chart shows a peculiar pattern of upper air flow: a strong upper air jet over northwestern Canada diverges into two distinct jets, one bending over the Pacific Ocean and looping southward over Lower California in a marked trough, then shoots northeastward over the United States. The second jet moves more directly from northwestern Canada south and east to New England where it merges with the Jet from the southwest. The trough over Lower California is associated with rather extensive precipitation over southwestern United States (note the movement of the surface low from the San Francisco area south to Los Angeles). The bifurcation of the jet in northwestern Canada has taken part of the continental Arctic air into northwestern United States (much of eastern Washington and Oregon and all of Idaho lies within the zero isotherm); the larger part of the continental Arctic air, however,

has moved southeastward into the United States; immediately north of Lake Superior a reading of −53° is observed on the map. Convergence of the two jets in eastern United States results in an extremely complex surface weather map: many frontal systems, several low centers, and extensive areas of precipitation bear witness to great activity in the upper air.

Spring (*Figure 3*)

March 14, 1957.—The 500 mbar constant pressure chart shows a rather simple pattern of a trough over the central and southern Rocky Mountains and a ridge over the eastern half of the United States. The trough insures extensive precipitation over the plains states largely in the form of snow for the air is still very cold. Although most concentrated in the neighborhood of the trough, the upper air jet stream is still effective enough in eastern United States to steer surface lows northeastward drawing warm, moist Gulf air as far north as Chicago where 70° was recorded. The presence of the subtropical high of the North Atlantic over a portion of the east coast of the United States resembles the "Heat Wave" situation which occurs several months later. The southern Appalachians receives heavy amounts of orographic precipitation as air moves from the subtropical high to the continental low.

Ridge—Trough Pattern (*Figure 4*)

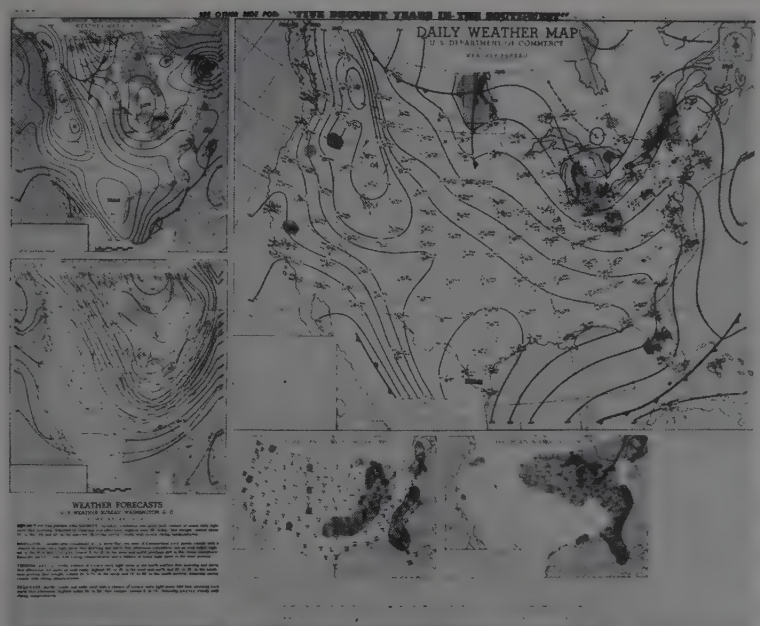
June 2, 1956.—A well-marked ridge in western United States, and an equally well-marked trough east of the Mississippi River introduce a marked contrast across the breadth of the country. Associated with the ridge at high levels in the west is dominantly fair weather with 90-degree readings extending northward to the Canadian border (Havre, Montana had 92°). Rather concentrated jet flow due south from the James Bay area to the Gulf of Mexico is in a position to dominate the weather of the Mississippi valley; readings in the 40's and 50's are common in the Great Lakes and Ohio River areas. The east side of the trough with a strong southerly flow from the Gulf of Mexico carries cloud and rain along the entire eastern seaboard.

Summer Heat Wave (*Figure 5*)

July 27, 1955.—Essentially a very simple pattern, the 500 mbar constant pressure chart shows most of the eastern half of the country is dominated by a massive ridge whose center lies over the southern Appalachians. A minor trough lies over the Pacific northwest, and the jet stream moves quickly around the southern edge of this trough and on into southern Canada leaving the continent north of Newfoundland. Heavy precipitation is concentrated in Washington and Oregon as a result of the trough aloft as well as the surface and upper level convergence features. Most of the remainder of the country is dominated by the subsiding air of the extensive high; winds aloft and at the surface are from a southerly direction, and Tropical maritime air is nearly everywhere. Ninety-degree readings cover two-thirds of the country, from California east and north to Montana and thence eastward to New England. Over 100-degrees was recorded as far north as Minneapolis and as far east as Milwaukee.

Early Fall (*Figure 6*)

August 19, 1956.—Fresh Polar continental air masses from north central Canada can easily invade the United States when the upper air pattern on the 500 mbar constant pressure chart shown here is dominant. Concentrated flow southward from northern Canada, and then eastward over northern United States brings daytime readings in the cool 70's southward to the Ohio valley, and nighttime readings in the low 40's to the Lake Superior area. Dominance of the high aloft over southeastern United States produces readings in the low 100's from the Rio Grande to the southern Appalachians; this area and the desert country in the far west remain the only areas to escape the cooling effect of the Canadian air.



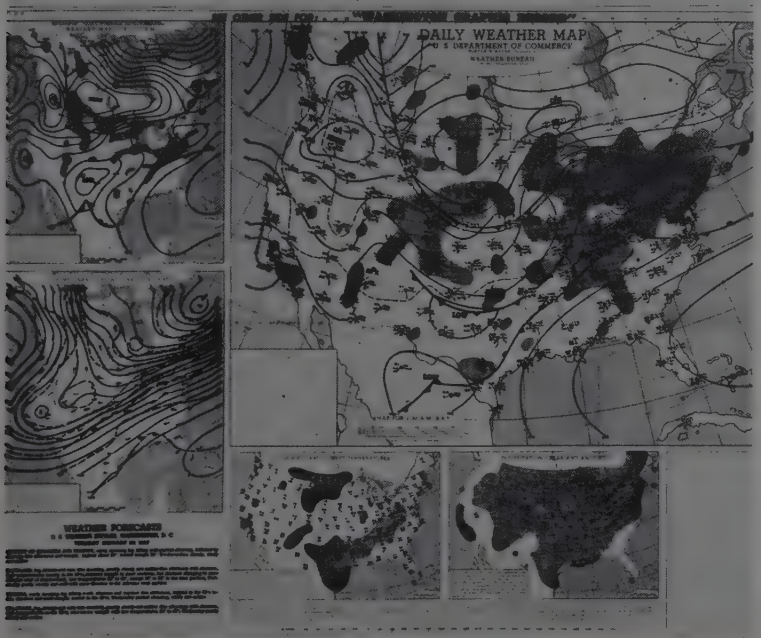
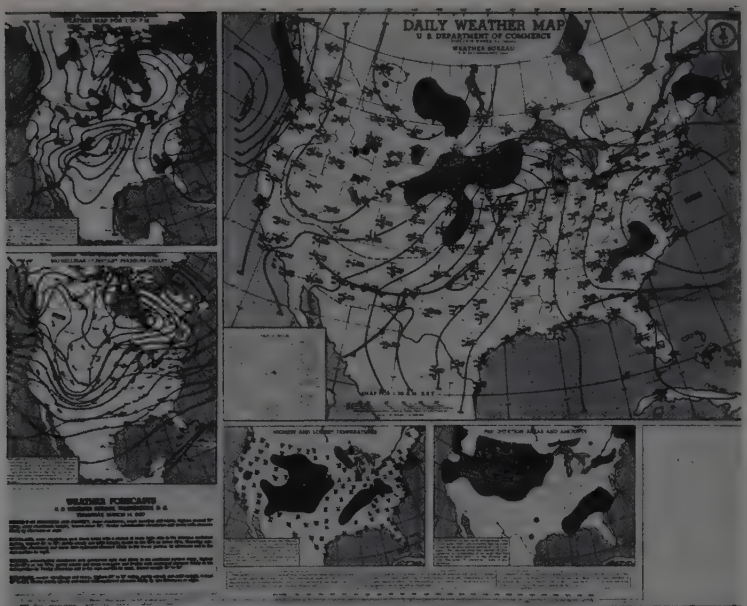


FIGURE 1 (top). FIGURE 2 (bottom).



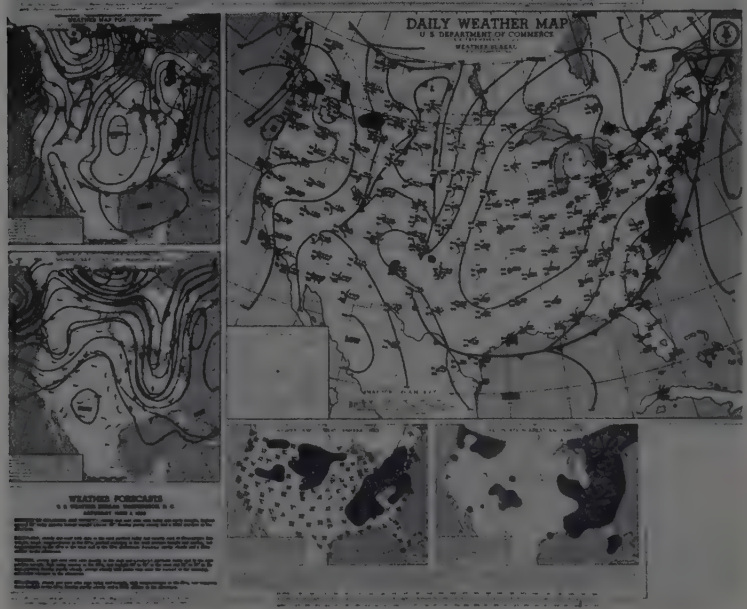
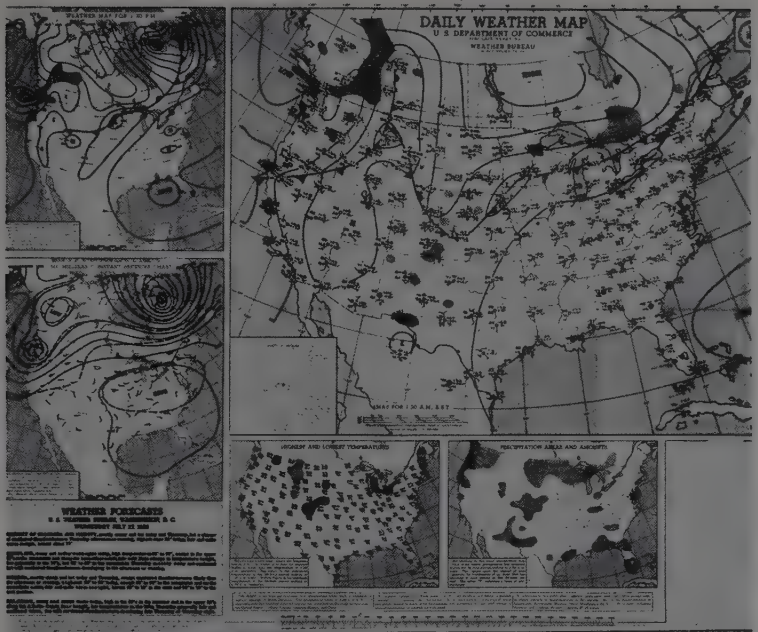


FIGURE 3 (top). FIGURE 4 (bottom).



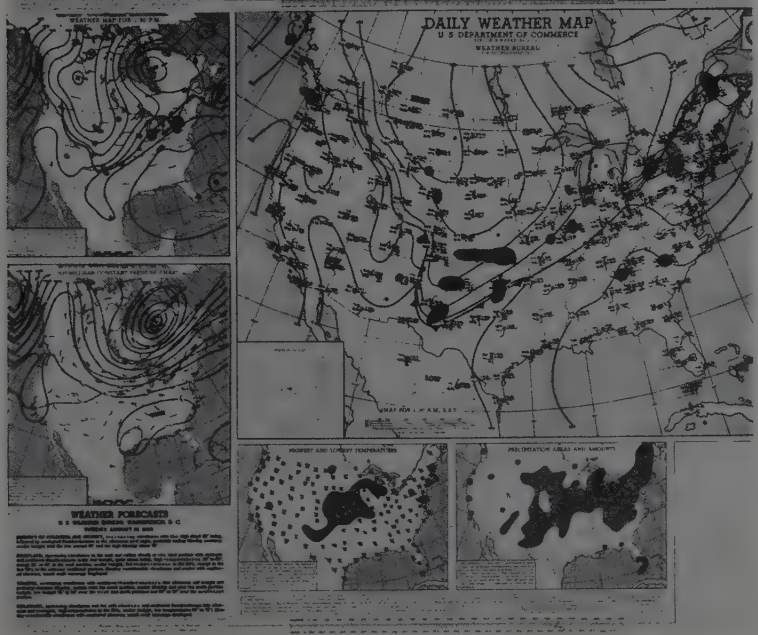


FIGURE 5 (top). FIGURE 6 (bottom).

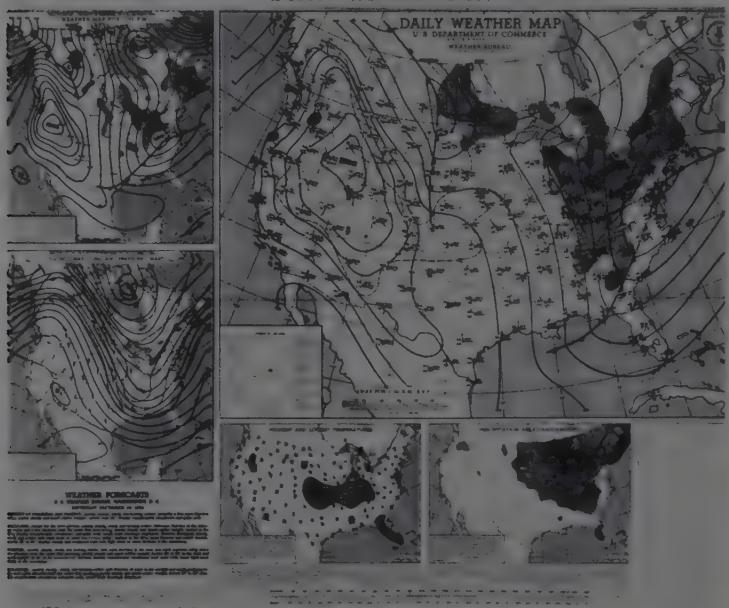


FIGURE 7 (top). FIGURE 8 (bottom).

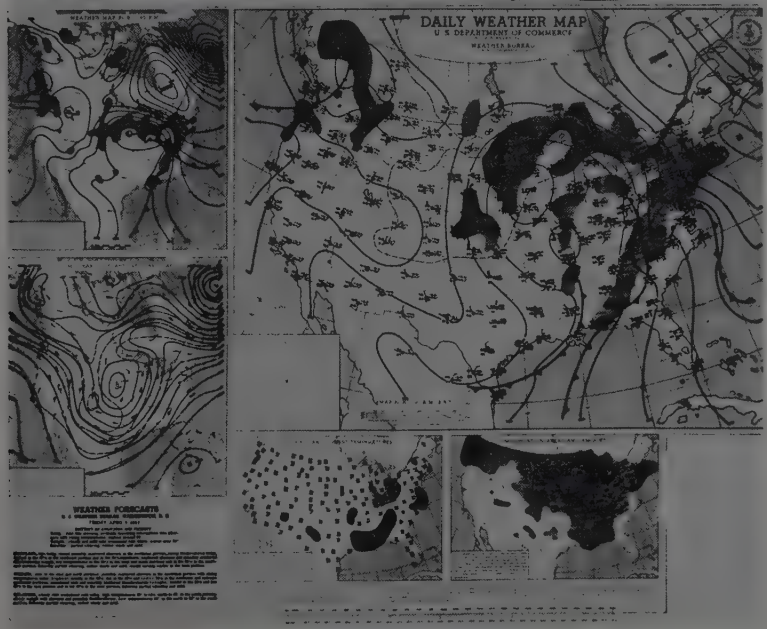


FIGURE 9 (top). FIGURE 10 (bottom).

Indian Summer (*Figure 7*)

October 28, 1956.—A well-defined trough in the western part of the United States and a ridge over the east succeeded by another trough off the Atlantic coast is the three-fold pattern on this map. The trough in the west is associated on the surface with extensive areas of precipitation from Washington west to eastern Montana and southward to southern California. Over most of the remainder of the United States high pressure at the surface and aloft and a weak low moving northeastward through the high plains resulted in mid-sixty degree readings from South Dakota eastward through Wisconsin and on to the Middle Atlantic states. Clear warm days and cool nights are the rule in most of the eastern half of the country. Off the east coast a late season tropical storm moves northward causing widespread cloud over the Atlantic and cloud and rain over the eastern portions of the Atlantic coastal states.

Chinook (*Figure 8*)

December 29, 1956.—A pronounced ridge pattern at the 500 mbar constant pressure level and a very strong surface anticyclone combine to produce the phenomenon called "chinook." The presence of the concentrated jet flow to the east of the Rocky Mountains steers cyclonic centers south and east of the highland barrier inducing a strong surface flow from the Great Basin country. Subsidence and divergence along the eastern margin of the Rockies produces temperatures in the low 60's from Colorado to northern Montana, but eastward temperatures remain in the mid-thirties to the Atlantic coast. The trough aloft over eastern United States combined with rapidly moving surface cyclones produce widespread cloud and precipitation in the form of rain and snow from the Great Lakes to the Atlantic and south to the Gulf of Mexico.

Flood Pattern (*Figures 9 and 10*)

April 4, 1957.—The 500 mbar constant pressure chart shows a concentrated flow of air entering the northwestern part of the United States and then looping southward in a huge continental sized trough which dominates the circulation pattern of the entire continent. As a result the nation is dominated by Polar maritime and Tropical maritime air; two-thirds of the country received precipitation during this regime. A well-developed cyclone moves northward along the eastern side of the trough drawing warm, humid air from the Gulf. Precipitation totals along the eastern side of the upper air trough exceeded one inch in 24 hrs from Columbus, Ohio to the lower Mississippi; amounts in excess of three in. were common in the Arkansas-Tennessee area.

April 5, 1957.—Stagnation of a distinct pattern is here illustrated; the trough evident in the preceding map is even more intensified the following day; the axis of the trough aloft has shifted slightly eastward, coinciding now with the Great Plains rather than the Rocky Mountains. The moisture-bringing effect to eastern United States is not much altered however. Forty-eight hr totals for representative stations include: Cincinnati 2.48 in.; Louisville 2.90 in.; Memphis 3.06 in.; and New Orleans 3.60 in. The combination of *two* factors is most significant in explaining the flood danger aspect here illustrated: (1) the distinctive atmospheric circulation pattern providing maximum potentiality for heavy precipitation in the eastern half of the country; and (2) the stagnation of that pattern over sufficiently long period of time to provide near disaster conditions on the earth's surface.

Although these maps have been selected to illustrate *familiar* case studies, it is important to note that each day's map allows a similar interpretation. Upper air phenomena and surface expression are irrevocably interdependent. To ignore one is to give only half the story; and, more particularly, to ignore the upper air phenomena is to ignore well more than half the story.

THE CHEMISTRY OF THE MEMBRANES OF THE EGG ENVELOPE OF *CRUZIA AMERICANA* MAPLESTONE, 1930

(NEMATODA: KATHLANIIDAE)

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The Membranes of the Egg Envelope

It is now generally recognized that the shell or egg envelope of nematode eggs consists of three layers of different chemical composition. These layers are: 1) the inner vitelline membrane; 2) the true shell; 3) the outer protein layer.

Cruzia americana Maplestone, 1930 was redescribed by Crites (1956). In this nematode, the sequence of development of the egg and its membranes is as follows: The egg cells are produced from the germinal epithelium at the distal end of the ovary. As they pass down the ovarian tube, along the side of the rachis, each egg accumulates yolk material forming a vitellus. Sections through the distal part of the growth zone of the ovary show no membrane around the vitellus at this point. In the proximal end of the ovary the vitellus becomes pyramidal in shape, containing a germinal condensation and a nucleus. The egg at this point is surrounded by a definite membrane, the vitelline membrane (fig. 1 to 5).

After the egg has entered the oviduct, the vitelline membrane can be seen clearly surrounding the yolk. The ovum begins to assume the oval shape typical of the genus *Cruzia*. Whether this change in shape results from the contraction of the vitellus or is caused by action of the oviduct is not known (fig. 5 to 8).

Sperm penetration occurs in the oviduct close to the ovary. The shell begins to form immediately afterward. The shell forms first as a thin layer, but later it thickens from 1 to 3 μ as the eggs pass down the oviduct. The author believes that the shell is of endogenous origin.

The protein coat is absent in eggs in the oviduct. This external layer forms around the egg in the distal end of the uterus. This covering thickens slightly and becomes ridged as the egg moves farther down the uterus. The protein coat is probably exogenous, being formed from a secretion of the uterine wall. In preparations stained with either mucicarmine or Erlich's glycerine alum haemotoxylin, the uterine wall shows droplets which stain with the same intensity as the protein coat of the egg. These stains, however, are not very specific, and this can be considered only as an indication that the outer coat is secreted by the uterine wall. The sculpturing of ridges in the protein coat is difficult to explain. Christenson (Chitwood and Chitwood, 1937) proposes that the mammillations of the eggs of *Ascaris* may be due to the basic principle of colloidal behavior. He believes that protein droplets accumulate around the shell, afterwards adhering and congealing and thus giving rise to a definite pattern. While the eggs are in the uterus, the vitellus shrinks away from the vitelline membrane leaving a fluid-filled cavity between it and the vitelline membrane, the perivitelline space. Walton (1924) reported that eggs of *Cruzia tentaculata* are oviposited while in a one-cell stage. The egg of *C. americana*, however, undergoes cleavage while in the uterus, and is oviposited while in a morula stage (fig. 11).

The Chemistry of the Egg Membranes

The chemistry of the egg membranes of *Cruzia americana* was investigated by using some of the tests applied by Chitwood (1938) and by Jones and Jacobs

(1939) to the egg membranes of other nematodes. These tests were supplemented by using histochemical methods. The materials used in the histochemical tests were either fresh and unfixed or fixed with a saturated solution of mercuric chloride. Tests were made at 23° C and 37° C, except when otherwise indicated.

The vitelline membrane.—(fig. 11). This membrane dissolved in absolute ether, chloroform, xylene, and acetone. It is insoluble in ten percent acetic acid, and is not dissolved by ten percent trypsin nor artificial gastric juice. The vitelline membrane is permeable to sodium hypochloride at 48° C and will melt when heated to 74° C. It is not stained by Sudan III or IV, but stains slightly with Sudan Black B. It does not dissolve in ten percent sodium-hydroxide or ten percent potassium-hydroxide. This membrane disappears, however, when the egg is heated to 160° C for 15 min in saturated potassium-hydroxide. The embryo inside the vitelline membrane does not stain when the eggs are treated with neutral red; but after treatment with fat solvents it stains readily with this dye. One the basis of these tests it is concluded that the innermost membrane is a lipid and probably a sterol or wax. Timm (1950) investigated the inner membrane of *Ascaris lumbricoides* var. *suis*, and on the basis of melting points concluded that it was a wax. He called this substance myricyl palmitate.

Shell proper.—The middle membrane, the shell, is insoluble in glacial acetic acid, ten percent sodium-hydroxide, and ten percent hydrochloric acid. It is not digested by artificial gastric juice. It gives a negative xanthoproteic test and a negative ninhydrin reaction. The shell dissolves in five percent sodium-hypochlorite in 30 min at room temperatures of 24 to 27° C. This membrane was tested for chitin, using the methods of Campbell (1929) and of Jones and Jacobs (1939). The eggs were heated in saturated potassium-hydroxide at 160° C for 15 min in a small, sealed capillary tube which was immersed in a glycerine bath. After such treatment, everything except the shell had disappeared. It stained brown in an iodine potassium-iodine solution, and it turned violet on the addition of dilute sulphuric acid. The shell dissolved in dilute acetic acid after treatment with potassium-hydroxide. The only substances known to withstand superheating with potassium-hydroxide are chitin and cellulose. In this case cellulose is eliminated, since cellulose is insoluble after treatment with potassium-hydroxide in dilute acetic acid. The shell stains a clear blue green with Alician blue, and it stains blue with Toluidine blue. It gives a negative Feulgen reaction, and stains purplish-red with periodic acid-Schiff (P.A.S.) treatment. These tests confirm the presence of carbohydrate material in the shell.

Eggs were removed from the ovarian end of the oviduct before the shell was formed. Some of these were submitted to the P.A.S. reaction and others to Alician blue. Both stains showed globules of carbohydrate material near the periphery of the vitellus. These globules appear in the very outer edge of the vitellus in eggs farther down the oviduct. They are much less numerous in eggs which have the shell completely formed, indicating that they probably give origin to the shell (fig. 5 to 9). Fauré-Frémiet believed that the egg shell of *Ascaris*

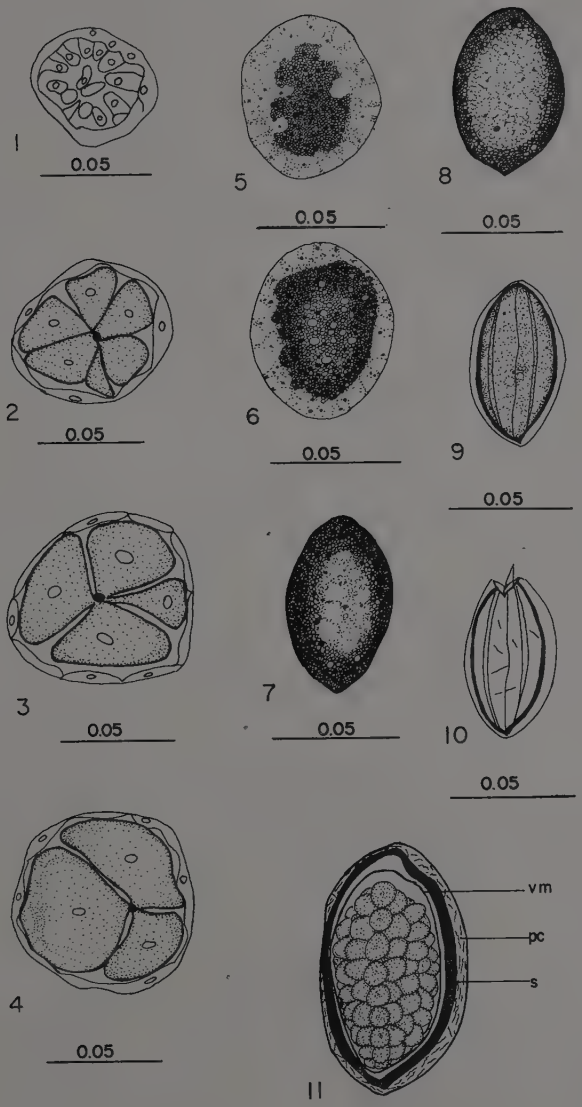
EXPLANATION OF FIGURES IN PLATE

(All scales in mm)

1. Ovary, germinal zone, cross section.
2. Ovary, distal end of the growth zone, showing developing ova around the rachis, cross section.
3. Ovary, cross section near middle of growth zone.
4. Ovary, proximal end of the growth zone, cross section.

5 through 9. These figures show the distribution of carbohydrate droplets in eggs from the upper oviduct to the uterus. Eggs from ovarian end of oviduct (fig. 5, 6). Eggs from uterine end of oviduct (fig. 7, 8). Egg from uterus (fig. 9).

10. Empty egg membranes, showing the rugosities and hatching orifice.
11. Morula stage, *VM*, Vitelline membrane; *S*, Chitinous shell; *PC* Protein coat.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lumbricoides was formed endogenously from glycogen. Alician blue shows only the presence of polysaccharides, and it is not specific for glycogen. The P.A.S. reaction gave a bright red color for glycogen, and the globules mentioned above stained purplish-red with this reaction. On the basis of the above tests it is concluded that the shell of the egg is chitin and that it is probably formed endogenously from carbohydrate materials in the vitellus; however, there is no positive evidence that this carbohydrate is glycogen.

The protein coat.—This outer coat dissolves in artificial gastric juice in three hours at room temperatures of 24° to 27° C. It dissolves in ten percent trypsin and also in one precent hydrochloric acid. It swells, but does not dissolve, in dilute acetic acid. One to three percent potassium-hydroxide dissolves the outer coat. It also is dissolved in picric acid. The membrane is not soluble in water. This outer coat gave a positive xanthoproteic test, turning orange in the presence of ammonia after being treated with warm nitic acid; it gave a ninhydrin test only with unfixed eggs, and even then only a slight diffuse blue color; and it turned orange when subjected to Millon's reagent. All of these tests indicate that this outer coat of the egg of *C. americana* is protein in nature.

On the basis of his findings, Chitwood (1938) concluded that the outer membrane of *Ascaris* eggs was not an albumin, collagen, fibroid, or keratin. He presumed that it might be a conjugated protein such as a mucoid. Wottage concluded, on the basis of staining results with Sudan III, that some lipoidal material is also present in this membrane in the eggs of *Ascaris*. The eggs of *C. americana* were tested further with histochemical test to check these possibilities. The outer membrane gave a negative Feuglen reaction, but it stained a light pink with the P.A.S. reaction, and also with mucicarmine. Toluidine blue gave a doubtful test on eggs fixed with mercuric chloride, the membrane sometimes staining a clear green and sometimes giving shades of rose. The membrane stained very lightly with Sudan III. On the basis of these tests, it was concluded that the outer coat of the eggs of *Cruzia americana* is probably a mucoprotein and that some lipoidal substances are present.

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SOME CAUSES UNDERLYING CELLULAR DIFFERENTIATION[1]

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In the stems of most plants we are likely to find large, as well as, small cells, short and elongate cells, cells with thick walls and those with thin walls. Some cell walls may be lignified while others are composed primarily of cellulose. Cells may be found whose walls show a pattern of pits or raticulae, or helices, or annular thickenings. Quiescent cells may lie beside those which are meristematic. Some cells contain no pigment while others may appear red, purple, or green. Cell shapes may vary from tissue to tissue and from cell to cell within each tissue. Dead cells lie along side of living cells. Why? How are we to explain these differences in form, chemistry, meristematic activity, and physiology?

We know, of course, that the gene compliment of a cell is one of the factors controlling its differentiation. If a corn plant lacks certain genes, it will be an albino, not green, regardless of the environment in which it is placed.

Environment also affects the course of differentiation. A corn plant kept in the dark during its entire life span will not be green, regardless of its genotype.

Either environment or genes may in some cases ultimately determine the course of differentiation. Furthermore, the rate and a degree of differentiation may be controlled either by environment or by heredity or by both. For instance, if the light intensity to which a plant is exposed is very low, its cells will produce very little chlorophyll and the plant will be light green rather than dark green. Similarly the cells of some genotypically different varieties of corn contain an abundance of chlorophyll and as a result, the plants are dark green. Corn plants of other varieties are never more than pale green, no matter to what environment they are exposed.

Many additional examples could be cited to illustrate the principle that the kinds of processes as well as the rates and/or duration of the processes are the results of differences in gene compliment or environment or both, and that these differences result in cells or groups of cells of invisibly different physiological states. It is, of course, these invisible differences in the complex of life processes of cells which preceed and are responsible for visible morphological differences. In other words, invisible *physiological differentiation* precedes and is causally related to visible *morphological differentiation.*

Differentiation then is a process or, more precisely, it is a complex of processes which are ultimately controlled by the environment and by the gene compliment. Furthermore, it is a progressive process. That is, it does not occur instantaneously but does occur over a period of time. Morphological differentiation may be rapid, slow, or saltatory.

This may be an appropriate time to consider the concept of dedifferentiation. It is difficult to understand how this term may be applied appropriately to a cell or to a group of cells. If morphological differentiation is the result of successive physiological changes, then dedifferentiation must imply that there has been an "undoing" or a reverse cancellation of each preceding physiological state. Obviously, this is impossible. Time cannot be recalled nor can an event occuring during the period of time with its accompanying effects be eliminated. It would seem that the inventor of this term ignored the fact that physiological change precedes morphological differentiation.

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A cell in which a process has occurred is not the same cell, physiologically speaking, as before. Let us consider a colorless cell in a leaf. The process of chlorophyll synthesis commences and continues until the cell is green. Later in the growing season the cell becomes colorless. Now, even though the cell may appear to have returned to its original state, microchemical examination of it would prove that this is not so. End products of chlorophyll disintegration will be found in the cell late in the season but not early in the season. Products formed during respiration will be different if the cell is observed both in the spring and in the fall. Very likely these differences will be both quantitative and qualitative. The cell has not become dedifferentiated. Differentiation has simply continued. Of course, as a result of continued differentiation, the cell may finally appear, superficially, as it did earlier in the differentiation process.

In considering the problem of cell, tissue, or organ differentiation within an individual plant or animal of a species, we are apt to disregard certain aspects of the causal factor, *heredity*. Gene compliment is frequently ignored because of the widely accepted assumption that, barring mutation, all somatic or vegetative cells, of which the individual organism is composed, are identical in-so-far-as gene compliment is concerned. This may not be an admissable assumption. Quite a few instances of naturally occurring supernumerary chromosome compliments have been found in scattered cells throughout a tissue, in certain tissues of an organ, and in specific organs of an individual. Instances of polysomaty are known from both the animal and plant kingdoms.

Therman and Timonen (1951) studied chromosome numbers in the cells of healthy humans. Cells of the skin, brain, liver, connective tissue, intestine, uterine epithelium, and other tissues were studied. They found that the chromosome number of the cells varied greatly, aneuploid numbers prevailing in all tissues. Furthermore, the most commonly encountered chromosome number for cells outside the sperm and egg line was not 48. They reported that the highest peak of frequency lies between 20 and 25 chromosomes and that there is a much lower frequency between 45 and 50 chromosomes.

Therman (1951) states "it can be regarded now as an established fact that differentiated tissues in insects represent various degrees of polyploidy and polyteny."

Polysomaty occurs to a greater or lesser degree as a regular developmental process in at least 19 genera of plants. Published results indicate that periblem is the tissue whose cells are most frequently polysomatic although polysomatic cells have been reported for the plerome of hemp, muskmelon, and spinach roots, the root cap of *Bryonia verrucosa*, and for the tapetum of spinach, dandelion, tomato, and the giant summer hyacinth (Lorz, 1947; Brabec, 1953).

In *Xanthisma texanum* and *Sorghum purpureo-sericeum*, cells of the shoots regularly contain more chromosomes than those of the roots (Berger et al., 1955).

Summarizing then, there is a very considerable body of evidence indicating that polyploidy and aneuploidy commonly occur in the various cells, tissues, and organs of many plants and animals, including *Homo sapiens*. This well documented but largely ignored fact leads one to consider the possibility that these variations in chromosome numbers may be causally related to cell, tissue, and organ differentiation.

If we assume that cells of an organ or a tissue are identical in chromosome compliment or if we admit that differences in chromosome compliments have not yet been shown to be causally related to differentiation, then how are we to explain such simple differences as those of cell size and cell wall thickness? It can be stated unequivocally that the apical meristems of shoots and roots exert a powerful influence, possibly complete control, over differentiation in shoots and roots of plants (Wetmore, 1956). Such a general statement, however, is in no sense a satisfying explanation of differentiation. This is particularly true if we

recall that a great deal of differentiation precedes the organization of root and shoot apices in the embryo.

Assimilation and diffusion of water are, of course, the processes immediately responsible for increases in wall thickness and cell enlargement. The assimilation of protoplasm, that is, the formation of additional protoplasm, is a complex and incompletely understood process. But we do know that foods, such as proteins, fats, and carbohydrates, as well as enzyme systems, must be present in the cell at least in minimal quantities before the process will occur. The manufacture by the cytoplasm of additional cell wall materials, such as lignin, cellulose, and pectic compounds, and the incorporation of these materials into the cell wall may, presumably, follow either of two courses. Particles of cellulose and other wall materials may be deposited among the constituent particles of the existing wall (intususception) or the wall materials may be deposited as additional layers on the inner face of the existing wall (apposition). In either event thickening or the extension of cell walls is dependant upon adequate supplies of certain foods and enzyme systems. Environmental factors, such as light, are known to influence not only rate of assimilation but also the course of cell wall differentiation. For instance, as the cell walls of cotton fibers thicken, the pattern of deposition of cellulose particles may be altered by light (Anderson et al., 1937). If the cotton plant is continuously illuminated, the fiber walls appear homogeneous when cross sections are examined under the microscope. Cotton plants exposed to alternating periods of light and darkness, on the other hand, produce fibers whose walls are conspicuously laminated. One lamella appears for each light-dark cycle as long as the wall is growing thicker. The more dense portion of each lamella is deposited during the light phase of the cycle.

In short, the initiation of, as well as, the subsequent rate of assimilation of a given cell component is dependant upon an adequate supply of the proper kinds of foods, enzyme systems, other internal environmental conditions, and external environmental conditions. Could we reasonably expect this multiplicity of factors to be identically balanced in the cells of two different plants? In two different organs of the same plant? In different tissues of the same organ? Or in adjacent cells of the same tissue? Not at all. These are some of the factors which certainly vary from cell to cell and consequently, in as much as they affect the kinds and rates of the processes, they must be responsible in some measure, for differentiation. We should *expect* cells to be different from one another, some physiologically different and others both physiologically and morphologically different.

It has already been suggested that diffusion of water into the vacuole or vacuoles of a cell is just as important as assimilation in the process of differential cell enlargement. The diffusion of water into or out of a cell and the rate of diffusion are dependent upon many factors some of which are the availability of water around the cell, the concentration of water in the vacuole vs. the concentration of water around the cell, the permeability of the differentially permeable cytoplasmic membrane and the plasticity of the permeable cell wall. Even though plenty of water enters the roots of a plant only minimal quantities may be available around most cells. If the rate of transpiration is high, very large quantities of water (125 gal per day for a palm tree) may enter the roots, be quickly pulled through the water conducting vessels of the roots, stems, and leaves, and just as quickly evaporate from the leaves into the surrounding atmosphere. In fact, more water may evaporate from the plant than enters the plant, resulting in wilting. Such environmental factors as light per se, temperature, and relative humidity affect the rate of transpiration, hence, the availability of water in the plant, and consequently differentiation of cells by means of cell enlargement. The concentration of water within the vacuole rarely remains constant. Solutes diffuse in and out of the cell and are constantly being used, or converted into

insoluble substance, or both. Insoluble foods may be digested to soluble foods and soluble sugars may be synthesized from water and carbon dioxide. The complex cytoplasmic membrane constantly undergoes alterations in the kind, quantity, and distribution of molecules of which it is composed. As a consequence its permeability is continuously changing. A given kind of molecule may pass through in large numbers, scarcely at all, or not at all depending upon the momentary composition of the membrane. Instability is the essence of this intricate mosaic of interacting molecules. Thickness of the cell wall and the balance existing between the various kinds of molecules of which the wall is composed are not the only factors determining wall plasticity. Naturally occurring hormones (auxins) are without doubt causally related to plasticity of cell walls. Cell elongation occurs only in the presence of auxins. However, concentration of auxin and the degree of plasticity of the wall are not necessarily directly related in a quantitative sense. The same concentration of auxin may result in different degrees of plasticity in different cell walls and relatively high concentrations may result in decreased wall plasticity.

It is, of course, entirely unrealistic to expect that all of these factors affecting cell enlargement would be the same for any two cells, even though the cells are gentically identical and located side by side. Therefore, we should be rather surprised to find two cells of the *same* size, shape, and wall thickness lying side by side rather than being astonished that the adjacent cells are morphologically different from each other.

There is much more to be said regarding the role of hormones in cell differentiation in plants. Hormones which are synthesized in stem tips, root tips, and both young and older leaves are necessary for cell division. Hence, they are responsible for the differentiation of meristematic cells from quiescent cells. If the tops of young sunflower seedlings are left undisturbed or if urine or indole-3-acetic acid is applied to the surface of the seedling axis after removal of the tops, a cylinder of meristematic cells (the vascular cambium) differentiates basipetally through the axis, (Snow, 1935). If the cut surface of the seedling axis is left untreated, the meristem does not form.

Reactivation of the cambium in a tree and the subsequent formation of additional xylem and phloem cells is an annual affair. This renewal of meristematic activity in a cylinder of previously meristematic cells is triggered by the renewed production of hormones in the terminal bud (Avery et al., 1937). As the hormone moves downward through the trees, cells of the cambium again become meristematic. Renewal of cambial activity finally occurs in the small roots of the tree.

Differentiation of root primordia from cells at the cut end of a stem is initiated by hormones produced in the stem tip and leaves, (Went et al., 1937). The transformation of mitotically inactive cells of almost any tissue of the stem into meristematic cells which become organized into a pattern characteristic of root tips, not stem tips, is a truly remarkable phenomenon.

We have known for 50 years that when a vein in a stem of a plant such as *Coleus* is cut and a mica plate is inserted in the incision to prevent grafting, cells of the pith, which would ordinarily have remained pith cells until the plant died, begin to divide. The resultant cells eventually differentiate into tissues characteristic of those in the vein. In other words an extension of the uppermost cut end of the vein differentiates downward through the pith, around the incision, until a union is established with the portion of the vein below the incision. It was discovered only a very few years ago that this remarkable resumption of cell differentiation, that is the differentiation of xylem cells from pith cells, is initiated by a hormone produced in the shoot apex and blades of leaves above the incision, (Jacobs, 1952). If the natural sources of hormone are removed and a synthetic hormone, indole-3-acetic acid, is applied, differentiation of xylem cells from pith cells occurs as before.

If cells from the cambium zone of lilac stems are cultured in vitro, a homogeneous callus of thin-walled cells develops. No vascular tissue differentiates from the cells even though the callus may live and grow for more than six years. However, if a shoot apex of lilac is grafted into a V-shaped groove cut into the callus, several strands of xylem cells differentiate basipetally in the callus from the lower end of the shoot apex. If a similar groove cut into the callus is filled with agar, no differentiation of xylem occurs. But if the groove is filled with agar containing indole-3-acetic acid, strands of xylem cells differentiate basipetally through the callus beginning at varying distances from the agar depending upon the concentration of hormone in the agar (Wetmore, 1956).

We might now turn our attention to the question, "how long does a cell retain its ability to differentiate?" In considering this question, we must keep in mind that when a cell divides, that cell no longer exists, but instead, two new cells come into being. The so-called Big Trees (*Sequoia gigantea*) of the western slope of the Sierra Nevadas may attain the age of more than 4,000 years. Yet it is extremely doubtful that any living cell in the tree is 4,000 years old. It is conservatively estimated that more than 90 percent of all cells in these trees are dead (and most of these dead cells lived for only a few weeks at most). Nevertheless, it is true that a relatively few cells in a Big Tree remain alive for about a century (Mac Dougal et al., 1927). These are cells of the xylem rays. There is no evidence, however, that these centenarians continue to enlarge, divide, or otherwise continue to differentiate after the first few weeks of their life.

There is a plant however, that attains the age of 150 years or more, most of whose cells remain alive from the time of their formation until the plant dies and decays (Mac Dougal, 1926). The plant, composed mostly of parenchyma, is the Giant Cactus (*Cereus giganteus*). Not only do the pith cells remain alive for more than 100 years but so do the cells of the epidermis, including the guard cells (Molisch, 1938). Both morphological differentiation and physiological differentiation continue during the course of life of these cells. Pith cells increase in size, their walls thicken, the glucose content increases, and there is a steady decrease in quantities of mucilages, fatty substances, and pentosans in the cells (Mac Dougal, 1926). Xylem and phloem cells continue to differentiate from pith cells as long as the tree lives. However, if an incision is made into the pith, cells which have remained nonmeristematic for more than a century, and would have remained so, had not the incision been made, begin to divide very rapidly and form a cambium. Cells which are formed by the cambium differentiate into cork cells.

The facts just stated and the events described, although remarkable, should not be surprising or unexpected. If it is true that a cell retains all of its chromosomes and genes until death, then we should expect it to retain all of its potentialities for differentiation for life. If the cell is subjected to the proper environment, we should expect any of these potentialities to be expressed. There is abundant evidence that this latter inference is true.

A given kind of cell or tissue may differentiate from any one of a relatively large number of tissues composing a plant. Cork cambium, for instance, may differentiate from cells of the epidermis, hypodermis, cortical parenchyma, endodermis, pericycle, phloem, xylem or pith of stems as well as, from many, if not all, tissues of roots, hypocotyls, leaves, fruits, and parts of flowers (Popham, 1952).

Whole plants may differentiate from the descendant cells of any one of many tissues of the plant. The phenomenon of vegatative propagation is evidence of this. Hundreds of square miles of important crop plants, such as, Irish potato, sugar cane, and sweet potato are propagated vegetatively by planting pieces of stems or roots. Complete new plants arise by proliferation and differentiation of a few cells of the propagule (Popham, 1952).

Cells of the root tip may differentiate physiologically and become reorganized into a shoot apex (Allen, 1947). Bud scale primordia may differentiate into leaves

(Steeves et al., 1957; Al-Talib, 1957). Leaf primordia may differentiate into bud scales, bracts, sepals, petals, or into complete new plants (Gabriel et al., 1957). Complete plants have grown, in vitro, from a 0.5 mm piece taken from the tip of a sunflower stem. In fact, complete plants of several different genera have grown from 0.25 mm slices taken from tips of stems of older plants of the same kind (Wetmore, 1956).

It was stated earlier that differentiation of a cell may be saltatory. We have already mentioned some examples of sudden, unexpected differentiation of cells. Pith cells in the stems of most plants remain pith cells until death of the plant. However, if a vein of the stem is cut, a strand of pith cells differentiates into thick-walled, lignified, elongate xylem elements. Differentiation of cells which have been pith cells for 100 years or more and could be expected to remain pith cells for at least another 50 years suddenly differentiate into highly meristematic cells of a cork cambium when an incision is made into the center of the stem of the giant cactus. A less dramatic but a much more frequently occurring example of saltatory differentiation may be found in the stems of perennials such as sycamore maple (Elliott, 1935) and arbor vitae (Bannan, 1955). At the end of each growing season, meristematic cells newly formed by, and on the phloem side of the vascular cambium, differentiate from meristematic cambium cells. Differentiation is by enlargement, some elongation, and thickening of the cell walls. Morphological differentiation apparently stops at this point and the cells remain in this condition during the winter months. Early in the following spring these cells undergo drastic physiological differentiation which results in morphological changes. To be more specific, these cells differentiate into highly specialized cells of the phloem.

With these examples of saltatory differentiation in mind, it may be profitable to examine our concept of *maturity*. When does a cell become mature? Is cell maturity a physical state or is it a physiological state? Is it possible to recognize a mature cell by examining it through the microsocpe? Is a mature cell large or small, thick or thin walled?

It would certainly seem that pith cells which change little, if any, in size, wall thickness, or any other morphological characteristic from a time shortly after they are formed until the plant dies and decays, are mature cells. Cells which remain pith cells for a hundred years or more certainly would be referred to as mature cells. Yet we have just concluded that they retain all of their potentialities until death. Furthermore, they do sometimes further differentiate and some of the long latent potentialities find morpholigical expression.

It would seem then, that maturity could be thought of as a state of physiological quiescence or even death whereas differentiation is a state of physiological activity. In a physiologically quiescent cell (a mature cell), processes may be thought of as occurring at the same rate or with so little variation in rate as to leave the cell unchanged morphologically. It is possible, of course, that processes, such as photosynthesis, might periodically start and stop without resulting in morphological change. On the other hand, cells in which the rates of the processes continue to accelerate and or in which new processes commence and continue, that is to say cells in which a physiological evolution or revolution is in progress, these are the cells which undergo morphological change and these are the ones which may be thought of as differentiating cells.

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General Zoology. *Claude A. Villee, Warren F. Walker, Jr.*, and *Frederick E. Smith.* W. B. Saunders Co., Phila., Penna. xix+877 pp. $7.50.

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THOMAS H. LANGLOIS

THE TOXICITY OF SOME AMINES FOR DUCKWEED, *LEMNA MINOR*

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The relation of the chemical structure of selective herbicides to their phytotoxicity has been extensively investigated, but relatively few studies have been published on the chemical groups responsible for nonselective phytotoxicity. This paper is concerned with the nonselective weed-killers, specifically, those connected with ammonium sulfamate. In a previous paper (Fromm and O'Donnell, 1951) the sulfonamide radical has been shown to be toxic in combination with a number of organic and inorganic groups which modify the magnitude of its phytotoxicity. Arenesulfonamides, e.g., benzenesulfonamide, were much more toxic than alkanesulfonamides, e.g., ethanesulfonamide. The toxicity of both, benzenesulfonamide and ethanesulfonamide, for duckweed became about ten times greater after introduction of an amino group in the organic radical (Fromm and O'Donnell, 1955). The question of whether this increased toxicity was caused by an additive or synergistic action of the two toxic groups (NH_2 and SO_2NH_2) or whether the amino group had no action of its own and served only as an auxotoxic agent, i.e., enhanced the action of the sulfamide group, was not answered.

For a better understanding of the effects of the two active groups in the same molecule, information about the phytotoxicity of aniline and ethylamine for duckweed seemed desirable. Cyclohexylamine and ammonium ion were also included in this investigation to give some idea about the action of amines in general. The test plant was a strain of *Lemna minor*, which had been used in previous research; the procedure was that described earlier (Fromm, 1955), but the experiments with ammonium chloride were preformed with a new strain of duckweed because the Mount Mercy strain did not acclimatize in Puerto Rico and had to be abandoned. These experiments with ammonium chloride were performed in the greenhouse of the Department of Botany and Plant Pathology, The Ohio State University, at an average temperature of 28°C and much better lighting than that available at Mount Mercy College. The average growth rate of the controls at Columbus was nearly twice that of the experiments at Pittsburgh, though it did not reach the optimum rate of 0.087 to 0.125 which Clark (1925) recorded under much better controlled conditions for the growth constant of *Lemna major*. The chemicals used were commercial products of c.p. quality; the aniline was applied as acetate, the other bases as chlorides since it was assumed that the toxic action of the salts depended only on the cation.

The results were expressed in terms of the equation $\log (N - N_0) = kt$, in which N_0 is the average number of fronds at the beginning of the experiment, N is their average number at the time t (in days), and k is a constant which represents the rate of growth. If k_0 is the constant of growth in the control solution and k that of the experimental solution, the value 100 ($k - k_0$) gives the growth in the experimental solution in percent of the control. Table 1, which includes also the probable error (σ^1) and the standard deviation (σ) of the average k and the T value as measure of the significance of the difference $k - k_0$ or $k_0 - k$, shows the results of representative series of experiments.

Aniline acetate in concentrations of 0.01M or more killed duckweed in 7 days or less. A solution containing 10^{-4}M aniline acetate had no significant effect

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while intermediate concentrations were growth-inhibiting. Hydrogenation of the benzene ring decreased the phytotoxicity slightly: the lethal action of 0.01M cyclohexylamine hydrochloride was slower than that of aniline of the same concentration, and the growth inhibition by a 10^{-3}M solution was less marked. A 10^{-4}M solution of the compound produced 127 percent of the growth of the control; i.e., it probably showed the effect of increased nitrogen supply. The pH of the solution affected the results. At pH 5.5, cyclohexylamine hydrochloride was definitely more toxic than at pH 6.8. Also, ethylamine hydrochloride killed duckweed in concentrations of 0.01M or more, but a 10^{-3}M solution did not

TABLE 1

Growth rate k and relative growth in per cent for Lemna minor *fronds in Clark solution with amines*

Compound	Molar Con.	$k \pm \sigma'$	σ	T	100 (k/k_0)	pH
†*$PhNH_2 \cdot AcOH$	0	0.0283 ± 0.0027	0.0089	——	100	6.7
$PhNH_2 \cdot AcOH$	7×10^{-2}	all dead on the 7th day		——	0	6.8
$PhNH_2 \cdot AcOH$	10^{-2}	begin to die on the 4th day; 2% of fronds surviving on 14th day		——	——	6.7
$PhNH_2 \cdot AcOH$	10^{-3}	0.0058 ± 0.0016	0.0052	8	20	6.7
$PhNH_2 \cdot AcOH$	10^{-4}	0.0221 ± 0.0031	0.0097	1.2	78	6.7
$C_6H_{11}NH_2 \cdot HCl$	0	0.0268 ± 0.0011	0.0034	——	100	6.8
$C_6H_{11}NH_2 \cdot HCl$	10^{-2}	begin to die on 7th day; 60% of fronds surviving on 15th day		——	——	6.7
$C_6H_{11}NH_2 \cdot HCl$	10^{-3}	0.0262 ± 0.0007	0.0020	0.46	98	6.9
‡$EtNH_2 \cdot HCl$	0	0.0238 ± 0.0016	0.0045	——	100	6.7
$EtNH_2 \cdot HCl$	10^{-1}	all dead on 9th day ——		——	0	6.8
$EtNH_2 \cdot HCl$	10^{-2}	all dead on 9th day ——		——	0	6.8
$EtNH_2 \cdot HCl$	10^{-3}	0.0220 ± 0.0015	0.0043	0.82	93	6.8
$EtNH_2 \cdot HCl$	10^{-4}	0.0286 ± 0.0009	0.0023	2.75	120	6.7
NH_4Cl	0	0.0508 ± 0.0017	0.0037	——	100	6.5
NH_4Cl	10^{0}	all dead on 7th day ——		——	0	6.4
NH_4Cl	10^{-1}	56% of fronds surviving on 9th day			——	6.4
NH_4Cl	10^{-2}	0.0212 ± 0.0023	0.0052	10.33	42	6.4
NH_4Cl	10^{-3}	0.0335 ± 0.0020	0.0045	5.83	70	6.4

†Ph—C_6H_5—
*Ac—CH_3COO—
‡Et—C_2H_5—

show any growth-inhibition and a 10^{-4}M solution produced a significant increase of the number of fronds over the control, presumably again on account of the better supply of nitrogen. Ammonium chloride also killed *Lemna minor* in concentrations of 0.1M or more and inhibited frond growth down to 10^{-3}M solutions. A 10^{-4}M ammonium chloride solution supplied additional nitrogen for increased growth.

The toxic effect of all four compounds for duckweed has thus been established. Qualitatively, the result is not entirely unexpected. Aniline has long been known to pharmacologists as a poison (Goodman and Gilman, 1955). It has also been reported to be poisonous to bean plants (Ciamician and Ravenna, 1920) and roots of *Lupinus albus* (Mary Chrysostom, 1936), where it leads to exosmosis and death. Cyclohexylamine is less toxic to man than aniline (Watrous and Schulz, 1950) and has been included in mixtures for thinning apples (Kenworthy, 1947) and for control of aquatic plants (Schmidl, 1950). Ciamician and Ravenna (1921) observed also phytotoxic action of ethylamine which was much more effective than methylamine or isoamylamine. Quantitatively, the toxicity of these amines was surprisingly high.

It may be concluded that the amino group as such is phytotoxic. Its activity is modified by the organic molecule to which it is attached and increases in the order alkyl-, cycloalkyl-, arylamine. Hence, in the case of the amino-substituted sulfonamides, tauramide and sulfanilamide, two phytotoxic groups are present in the molecule. Previous investigations (Fromm and O'Donnell, 1953) of the simultaneous action of *p*-aminobenzoic acid and sulfanilamides on duckweed have already shown that there is little antagonism between the two compounds in their effects on plants. This is interpreted as indicating that the major source of phytotoxicity is the sulfonamide group [which possibly interferes with the plant carbonic anhydrase (Fromm and O'Donnell, 1955)] while the amino group is an additional agent which might compete with *p*-aminobenzoic acid. It is tempting to speculate whether the approximately tenfold increase of phytotoxicity produced by the amino group in organic sulfonamides represents a quantitative relation in the activity of the two groups or not, but the available data are not ample enough for a conclusion.

SUMMARY AND CONCLUSIONS

Lemna minor was killed by M ammonium chloride, 0.01M ethylamine, 0.01M aniline, and about the same concentration of cyclohexylamine. The amino group as such is phytotoxic; its effect increases with the organic group to which it is attached in the order ethyl, cyclohexyl, and phenyl radical. In compounds substituted by both amino and sulfonamide groups, both radicals contribute to the toxic action but the effect of the sulfonamide prevails.

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THE VASCULAR FLORA OF THE VINTON FURNACE EXPERIMENTAL FOREST[1]

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INTRODUCTION

In 1952 the U. S. Forest Service leased an area of 1200 acres in Vinton County, Ohio, for long-range studies in forest management. The writer first visited the Vinton Furnace Experimental Forest in 1955 and was struck by the great variety of native vascular flora present. The role of the Forest as a laboratory-in-the-woods where careful ecological studies were being initiated made a floristic inventory of the tract seem desirable. In addition, almost half of the species occurring had yet to be reported for Vinton County. Twenty-eight additional collecting trips to the area followed, resulting in the present study.

LOCATION AND TOPOGRAPHY

The Forest lies southeast of McArthur in sections 19, 25, and 31 of Madison Township and sections 30 and 36 of Vinton Township. Adjoining are the Raccoon State Forest and extensive tracts owned by the Baker Wood Preserving Company, which leased the study area to the Forest Service.

The area lies in the Unglaciated Allegheny Plateau and is much dissected into long ridges and steep-sided ravines, the higher ridges reaching 980 ft. Surface strata are Pennsylvanian in age, consisting almost entirely of the Allegheny series. Large sandstone outcrops on the ridge in the northeast corner of the forest are well known locally as the Watch Rocks.

Elk Fork and its tributary Pine Run drain the area and form the north and west boundaries. Elk Fork is heavily polluted with acid mine waters and is nearly devoid of aquatic life, though the small rocky streams of the ravines are clean. The elevation of the Elk Fork valley is 680 ft, giving an area relief of 300 ft.

HISTORICAL BACKGROUND

In the early 1850's, many iron furnaces were erected in southeastern Ohio, including the Vinton Furnace just northwest of the present forest. The virgin stands of timber in the surrounding areas were destroyed for charcoal and soon after the Civil War, the furnaces were abandoned. Most of the timber presently on the Vinton Forest apparently dates from a clearcut made during this period.

With depletion of the better timber and coal and widespread erosion, Vinton County suffered economic decline and land abandonment. Apparently there were never homesteads on the forest area proper although county roads crossed it. Today no occupied houses exist for several miles.

Activities of the Forest Service on the area have included installation of deep wells, run-off troughs, and nine weather stations, and the construction of roads and a Headquarters building. Soils, water relations, methods of stand improvement and of logging are under study. Experimental plots have been subjected to a variety of treatments, including complete clearcut, commercial clearcut, diameter limit cut, selective cut with stand improvement, and conversion from hardwoods to pine. The outcome of this research is of course many years in the future.

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[1]Extracted from a Master's thesis presented to Ohio University, February 2, 1957.

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VEGETATION PATTERNS

The present vegetation may be divided arbitrarily into five major groupings: ridge forest, upland clearings, ravines, open bottomlands, and forested bottomlands.

The ridges and upper slopes are dominated by oaks, chiefly *Quercus alba*, *Q. prinus*, *Q. velutina*, and *Q. coccinea*. Other common or characteristic species include *Pinus rigida*, *P. echinata*, *Carya ovata*, *Quercus stellata*, and *Cornus florida*. On the more acid slopes, ericads such as *Oxydendrum arboreum*, *Kalmia latifolia*, and *Vaccinium vacillans* are conspicuous. Characteristic herbs include *Danthonia spicata*, *Gillenia stipulata*, *Tephrosia virginiana*, *Desmodium nudiflorum*, *Oxalis violacea*, *Houstonia caerulea*, *Cunila origanoides*, *Antennaria plantaginifolia*, and *Hieracium venosum*. *Cladonia* lichens and mosses such as *Dicranum scoparium*, *Leucobryum glaucum*, *Ditrichum pallidum*, and *Polytrichum ohioense* form extensive mats in the dry soil.

Upland clearings include disturbed roadsides, experimental plots, and two old fields. The flora of the roadsides and plots is a heterogeneous assemblage marked by such coarse species as *Pteridium aquilinum*, *Phytolacca americana*, *Sassafras albidum*, *Rubus* spp., *Lespedeza* spp., *Apocynum cannabinum*, *Helianthus* spp., *Solidago* spp., *Aster* spp., *Erigeron canadensis*, and *Erechtites hieracifolia*. Weeds of foreign origin are invading although many have not yet spread beyond the point of introduction, e.g., *Barbarea vulgaris*, *Agrostemma githago* and *Rumex mexicanus* which are confined to a spot where hay had once been spread; *Capsella bursa-pastoris*, *Plantago rugelii*, three species of *Veronica*, and *Taraxacum officinale* which were found only in the lawn at Headquarters. The "north old field" is a small opening dominated by *Andropogon scoparius*. Also prominent are *Hypericum spathulatum*, *Spiraea tomentosa*, and *Solidago juncea*. A larger grassy area, the "south old field," lies along the southern border of the tract. Only the portion immediately adjacent to the Forest entrance was included in this study.

The ravines and lower slopes support a rich mixed mesophytic forest. Among the many canopy species are *Juglans cinerea*, *Carya cordiformis*, *Fagus grandifolia*, *Quercus alba*, *Q. rubra*, *Liriodendron tulipifera*, *Acer saccharum*, *Aesculus octandra*, and *Tilia americana*. Dominating the forest floor are ferns and a wide variety of vernal herbs such as *Erythronium americanum*, *Trillium grandiflorum*, *Orchis spectabilis*, *Claytonia virginica*, *Sanguinaria canadensis*, *Dentaria heterophylla*, *Tiarella cordifolia*, *Viola canadensis*, and *Phlox divaricata*. Two rarer Appalachian species occurring here are *Phlox stolonifera* and *Meehania cordata*.

Open bottomland consists of intermittent openings on the Pine Run-Elk Fork floodplain. Favorable light and moisture conditions result in a rank herbaceous vegetation interspersed with alder thickets and young trees. Characteristic species include *Onoclea sensibilis*, *Panicum clandestinum*, *Carex* spp., *Polygonum* spp., *Agrimonia rostellata*, *Impatiens* spp., *Galium asprellum*, *Sambucus canadensis*, *Eupatorium* spp., *Aster puniceus*, and *Actinomeris alternifolia*.

Forested bottomland includes most of the Pine Run-Elk Fork floodplain with extensions into the larger ravines. *Salix nigra*, *Betula nigra*, *Ulmus americana*, *Platanus occidentalis*, *Acer saccharinum* and *Fraxinus americana* mark the canopy. Herbs include *Ranunculus septentrionalis*, *Cardamine bulbosa*, *Sedum ternatum*, *Geum canadense*, *Viola papilionacea*, *Cryptotaenia canadensis*, *Lysimachia ciliata*, *Mertensia virginica* and many coarser species shared with the preceding habitat grouping.

LIST OF SPECIES

Records of 536 species representing 314 genera of 95 families are substantiated by specimens collected by the writer and deposited in the Herbarium of Ohio University. A few additional, incomplete records are also mentioned. Nomenclature and sequence follow Fernald (1950) with the nominate race of a polytypic

species indicated by "(typical)" after the name. Relative abundance is given although habitat information is included only for the less frequent species. Collection numbers of specimens are cited. With the exception of *Panicum*, *Carex*, *Rubus*, and *Crataegus* which are admittedly incomplete, the list below is believed to be a nearly exhaustive catalog of the vascular flora actually occurring on the forest at present.

Lycopodiaceae.—Lycopodium lucidulum (typical), one large colony in a moist rocky ravine; 1157. *L. complanatum* var. *flabelliforme*, scattered extensive colonies; 1007, 1337.

Ophioglossaceae.—Xotrychium dissectum, occasional, chiefly the "oblique-lobed" rather than the typical form; 1447, 2258. *B. virginianum*, common; 1142.

Osmundaceae.—Osmunda claytoniana, common; 1195. *O. cinnamomea*, fairly common; 1176.

Polypodiaceae.—Woodsia obtusa, a few individuals on a moist sandstone outcrop; 1302. *Cystopteris fragilis* var. *protrusa*, common; 1148. *Onoclea sensibilis*, common; 1293. *Dryopteris noveboracensis*, very common; 1284. *D. hexagonoptera*, fairly common; 1145. *D. spinulosa* var. *intermedia*, a few with the *Lycopodium lucidulum* colony; 2179. *D. goldiana*, several in a partly-open ravine-bottom; 1385. *D. marginalis*, fairly common; 1301. *Polystichum acrostichoides*, very common; 1381. *Dennstaedtia punctilobula*, several individuals in recent clearings on "Yellow-jacket Ridge" in the southwest corner of the Forest; 1899. *Athyrium pycnocarpon*, uncommon; 2048. *A. thelypterioides*, fairly common; 1985. *A. filix-femina* var. *michauxii*, fairly common; 1942, 1982. *Camptosorus rhizophyllus*, occasional; 1001. *Asplenium pinnatifidum*, a few in niches of the Watch Rocks; 1297. *A. platyneuron*, fairly common; 1400, 2155. *Pellaea atropurpurea*, a few on a sandstone outcrop south of the Watch Rocks; 1660. *Adiantum pedatum*, common; 1837. *Pteridium aquilinum* var. *latiusculum*, common; 1137. *Polypodium virginianum*, common; 1004.

Pinaceae.—Tsuga canadensis, a young stand and scattered older trees along Elk Fork; 1360. *Pinus echinata*, fairly common; 1390. *P. rigida*, fairly common; 1115. Seedlings of *P. strobus* have been planted in some experimental plots.

Typhaceae.—Typha latifolia, a few in wet roadside depressions; 1639, 1900.

Sparganiaceae.—Sparganium sp., a large sterile colony along Elk Fork; 2086.

Alismataceae.—Sagittaria australis, a colony at the mouth of Pine Run and a second along Elk Fork; 1627, 2087.

Gramineae.—Bromus purgans, fairly common; 2254. *Festuca obtusa*, uncommon; 1133. *Vulpia octoflora*, scattered colonies; 1947. *Glyceria striata* (typical), fairly common; 1292. *Poa compressa*, common; 1889. *P. cuspidata*, fairly common; 1002, 1060. *Eragrostis capillaris*, occasional; 2038. *Triodia flava*, chiefly roadsides in the south old field; 2069. *Elymus riparius*, fairly common; 1977. *Hystrix patula* (typical), common; 1320. *Sphenopholis nitida*, a few scattered colonies; 1073. *Danthonia spicata* (typical), very common; 1163. *Calamagrostis insperata* Swallen, several small colonies in ridgetop clearings just north of Forest Headquarters; 1392A, 1945. Although apparently included in *C. porteri* Gray by Fernald (1950), this species is considered distinct by Hitchcock (1950) and other authorities. *C. insperata* has been reported previously only from the type locality of Ophir Hollow, Jackson County, Ohio, and from two stations in Missouri (Van Schaak, 1954). *Agrostis alba* (typical), chiefly roadsides in the south old field; 1894. *A. perennans*, very common; 2039, 2145. *Cinna arundinacea*, uncommon; 2206, 2253. *Phleum pratense*, uncommon; 1876. *Muhlenbergia tenuiflora*, common; 2034. *M. sylvatica*, fairly common; 2201. *Aristida oligantha*, restricted to the south old field; 2192. *A. longespica*, with the preceding; 2196. *Eleusine indica*, a stray individual in road in the south old field; 2191. *Leersia virginica* var. *ovata*, common; 2051. *Digitaria ischaemum*, common on disturbed roadsides; 2083. *D. sanguinalis*, with the preceding; 2084. *Paspalum ciliatifolium* var. *muhlenbergii*, a small colony on roadside in the south old field; 2190. *Panicum dichotomiflorum* var. *geniculatum*, occasional; 2199. *P. capillare* (typical), a few along road in the south old field; 2225. *P. stipitatum*, a stray individual along Elk Fork; 2082. *P. dichotomum* (typical), very common; 1166, 1374. *P. polyanthes*, uncommon; 2079. *P. commutatum* (typical), fairly common; 1132. *P. clandestinum*, very common; 2231. *Echinochloa pungens* (typical), occasional; 2188. *Setaria glauca*, roadsides in the south old field; 2187. *S. viridis* (typical), a few with the preceding; 2184. *Andropogon scoparius*, very common; 2053. *A.*

gerardi, one colony in a ridgetop clearing; 1560. *A. virginicus* (typical), common; 2197, 2227. *A. elliottii*, only in the south old field; 2228.

Cyperaceae.—Cyperus flavescens var. *poaeformis*, occasional along Pine Run; 2232A. *C. strigosus* (typical), occasional; 2232. *Eleocharis obtusa*, occasional; 2233. *Scirpus atrovirens* var. *georgianus*, occasional; 1274. *S. rubricosus*, a small colony in a wet roadside depression on Yellow-jacket Ridge; 2241. *Carex rosea*, fairly common; 1289. *C. crinita* (typical), occasional; 1848. *C. hirsutella*, common; 1161. *C. prasina*, fairly common; 1175. *C. plantaginea*, fairly common; 1709. *C. lurida*, occasional; 1328. *C. lupuliformis*, occasional; 2167.

Araceae.—Arisaema atrorubens, fairly common; 1080. *A. dracontium*, occasional,. valley of Pine Run; 1177, 1986.

Commelinaceae.—Tradescantia virginiana, uncommon; 1153, 1801.

Juncaceae.—Juncus tenuis, very common; 1129, 1880. *J. effusus* var. *solutus*, fairly common; 1327. *J. biflorus*, one large colony in moist open soil on Yellow-jacket Ridge; 2080. *J. acuminatus*, one small colony; 1326. *Luzula echinata*, common; 1059.

Liliaceae.—Chamaelirium luteum, fairly common; 1144. *Uvularia perfoliata*, common; 1800. *U. grandiflora*, fairly common; 1051. *Allium canadense*, one colony on terrace along Elk Fork; 1853. *Lilium canadense* var. *editorum*, fairly common; 1453. *Erythronium americanum*, common; 1704. *E. albidum*, fairly common; 1705. *Smilacina racemosa* var. *cylindrata*, common; 1146, 1796. *Polygonatum biflorum*, fairly common; 1074. *P. canaliculatum*, occasional; 1881. *Medeola virginiana*, fairly common; 1159. *Trillium flexipes*, one colony; 1083, 1802. *T. grandiflorum*, very common; 1053. *Smilax herbacea*, occasional along Pine Run; 1178. *S. rotundifolia*, very common; 2198. *S tamnoides* var. *hispida*, fairly common; 2250. *S. glauca* var. *leurophylla*, common; 2166.

Dioscoreaceae.—Dioscorea villosa, uncommon; 1335, 1844.

Amaryllidaceae.—Hypoxis hirsuta, one colony; 1077.

Iridaceae.—Sisyrinchium angustifolium, a few in the north old field; 1279. *Iris cristata*, scattered colonies along Elk Fork; 1804.

Orchidaceae.—Cypripedium calceolus var. *pubescens*, occasional; 1110. *Orchis spectabilis*, occasional; 1456, 1797. *Isotria verticillata*, fairly common, in association with *Kalmia*; 1294, 1805. *Spiranthes tuberosa*, occasional; 2065. *S. vernalis*, a few in the south old field; 2062. *Goodyera pubescens*, fairly common; 1458. *Corallorhiza odontorhiza*, occasional; in part the yellowish forma *flavida*; 1631 *Malaxis unifolia*, fairly common; 1361. *Liparis lilifolia*, occasional; 1138. *Aplectrum hyemale*, occasional; 1673. *Tipularia discolor*, one small colony; 1008.

Salicaceae.—Salix nigra, fairly common; 1846. *S. sericea*, collected once; 1819. *S. humilis*, uncommon; 1994 *S. tristis* Ait. [*S. humilis* var. *microphylla* in Fernald (1950)], a few along upper border of the north old field; 1706. *Populus grandidentata*, fairly common; 1884.

Juglandaceae.—Juglans cinerea, fairly common; 2175. *J. nigra*, uncommon; 2257. *Carya cordiformis*, uncommon; 2249. *C. ovata*, fairly common; 2229. *C. tomentosa*, fairly common; 2244. *C. glabra* (typical), common; 2224.

Corylaceae. -Corylus americana, common; 1465. *Ostrya virginiana*, collected only once but probably commoner; 2263. *Carpinus caroliniana* var. *virginiana*, common; 1149. *Betula nigra*, fairly common; 1849. *Alnus serrulata*, common; 1662.

Fagaceae.—Fagus grandifolia, uncommon; 1286. *Castanea dentata*, fairly common, short-lived sprouts only; 1140. *Quercus alba*, very common; 2211. *Q. stellata*, uncommon; 1372. *Q. prinus*, very common; 2212. *Q. muehlenbergii*, no specimens. *Q. rubra* (typical), common; 2217. *Q. coccinea*, common; 2215. *Q. velutina*, very common; 2216. *Q. imbricaria*, uncommon, chiefly along Pine Run; 1288.

Ulmaceae.—Ulmus rubra, fairly common; 2159. *U. americana*, fairly common; 2267.

Moraceae.—Morus rubra, occasional; 1123.

Urticaceae.—Laportea canadensis, fairly common; 1979. *Pilea pumila* (typical), common; 1553. *Boehmeria cylindrica* (typical), fairly common; 1624. *Parietaria pensylvanica*, one colony near the Watch Rocks; 1398.

Aristolochiaceae. Asarum canadense (typical), common; 1052. *Aristolochia serpentaria*, fairly common; 1838.

Polygonaceae. Rumex mexicanus, one small colony on Yellow-jacket Ridge; 1898. *R.*

obtusifolius, occasional; 1866, 1980. *R. acetosella* (typical), fairly common; 1116. *Tovara virginiana*, common; 1459, 1979. *Polygonum aviculare*, a few at Headquarters; 1875. *P. pensilvanicum* var. *laevigatum*, occasional; 2185. *P. persicaria* (typical), fairly common; 1350. *P. punctatum* var. *leptostachyum*, uncommon; 1992, 2230. *P. sagittatum*, fairly common; 1987. *P. arifolium* var. *pubescens*, occasional; 2172. *P. scandens*, common; 1618.

Chenopodiaceae.—Chenopodium hybridum var. *gigantospermum*, one colony; 1462. *C. album*, uncommon; 1461, 1868.

Phytolaccaceae.—Phytolacca americana, common; 1268.

Portulacaceae.—Claytonia virginica, common; 1006.

Caryophyllaceae.—Paronychia canadensis, common; 1167. *P. fastigiata*, one stray individual; 2055. *Stellaria pubera* var. *silvatica*, fairly common; 1084. *S. longifolia*, uncommon; 1113. *Cerastium nutans*, a single colony; 1820. *C. viscosum*, occasional; 1789. *Agrostemma githago*, a few individuals on Yellow-jacket Ridge; 1356. *Silene stellata*, fairly common; 1319. *S. virginica*, fairly common; 1109. *Dianthus armeria*, fairly common; 1343.

Ranunculaceae.—Ranunculus recurvatus, common; 1158. *R. hispidus*, one small colony; 1793. *R. septentrionalis* (typical), fairly common; 1750. *Thalictrum polygamum*, common; 1330. *Anemonella thalictroides*, common, sometimes flowering in the fall; 1046. *Anemone virginiana*, no specimens. *Hepatica americana*, fairly common; 1005. *Clematis virginiana*, common; 1441, 1616A. *C. viorna*, fairly common; 1334. *Cimicifuga racemosa*, common; 1336.

Berberidaceae.—Podophyllum peltatum, common; 1338, 1803. *Jeffersonia diphylla*, one colony; 1396. *Caulophyllum thalictroides*, occasional; 1395.

Menispermaceae.—Menispermum canadense, fairly common, 2164.

Magnoliaceae.—Liriodendron tulipifera, common; seedlings are often abundant in recent clearcuts; 2160.

Annonaceae.—Asimina triloba, fairly common; 1816.

Lauraceae.—Sassafras albidum var. *molle*, very common; 1941, 2045. *Lindera benzoin*, very common, the leaves varying from moderately pubescent to glabrous beneath; 1710, 1845.

Papaveraceae.—Sanguinaria canadensis, common; 1050, 1836. *Dicentra cucullaria*, fairly common; 1712.

Cruciferae.—Lepidium campestre, a few on roadside on Yellow-jacket Ridge in the southwest corner of the area; 1795. *Capsella bursapastoris*, a few at Headquarters; 1790. *Brassica kaber* var. *pinnatifida*, one colony on Yellow-jacket Ridge; 1351A. *Sisymbrium officinale* var. *leiocarpum*, a few at Headquarters; 1872. *Barbarea vulgaris* var. *arcuata*, a few on Yellow-jacket Ridge; 1792. *Dentaria laciniata*, very common; 1041. *D. heterophylla*, common; 1054. *Cardamina bulbosa*, common; 1112. *C. douglassii*, common; 1058, 1711. *C. pensylvanica* (typical), fairly common; 1798. *C. parviflora* var. *arenicola*, one large colony near Headquarters; 1791. *Arabis laevigata* (typical), fairly common; 1049. *A. canadensis*, fairly common; 1107, 1130.

Crassulaceae.—Sedum ternatum, very common; 1076.

Saxifragaceae.—Saxifraga virginiensis, common; 1075. *Tiarella cordifolia*, very common; 1079. *Heuchera americana*, fairly common; 1072. *Hydrangea arborescens*, common; 1282.

Hamamelidaceae.—Hamamelis virginiana, common; some of the material approaches the variety *parvifolia*; 1661, 2209.

Platanaceae.—Platanus occidentalis, fairly common; 1847.

Rosaceae.—Spiraea tomentosa, only in the north old field; 1452, 2052. *Aruncus dioicus*, fairly common; 1156. *Gillenia stipulata*, very common; 1160. *Pyrus coronaria* var. *lancifolia*, fairly common; 2068. *Amelanchier arborea*, fairly common; 1703. *Crataegus* spp., fairly common but largely immature; 2137. *Fragaria virginiana* var. *illinoensis*, one small colony on the Forest; the species is common on roadsides nearby; 1882. *Potentilla norvegica*, uncommon; 1389. *P. simplex* (typical), common; 1085. *Geum canadense*, common; 1333, 1976. *G. virginianum*, occasional; 1903. *Rubus occidentalis*, uncommon; 2174. *Rubus* sp. (dewberry), in the north old field; 1821. *Rubus* sp. (blackberry), common; 1896. *Agrimonia parviflora*, fairly common; 2158, 2170. *A. rostellata*, occasional; 2032. *A. pubescens*, fairly common; 1448, 2035. *Rosa carolina*, very common; 1128. *Prunus serotina*, uncommon; 2156.

Leguminosae.—Cassia nictitans, common; 1450. *Cercis canadensis*, very common; 1936. *Trifolium pratense* var. *sativum*, uncommon; 1170. *T. repens*, chiefly around Headquarters;

1877. *T. reflexum* (typical), collected once near the Watch Rocks; 1299. *T. hybridum* var. *elegans*, occasional near Headquarters; 1887. *T. agrarium*, a few in the north old field; 1280. *Melilotus officinalis*, occasional near Headquarters; 1871. *M. alba*, fairly common; 1387. *Medicago lupulina* var. *glandulosa*, a few in the Headquarters lawn; 1870. *Tephrosia virginiana* (typical), fairly common; 1269. *Robinia pseudo-acacia*, occasional; 2142. *Desmodium nudiflorum*, very common; 1322. *D. glutinosum*, common; 1349. *D. rotundifolium*, uncommon; 2042. *D. ciliare*, fairly common; 2047, 2070. *D. marilandicum*, uncommon; 2144. *D. cuspidatum* (typical), fairly common; 1376, 2040. *D. glabellum*, uncommon; 2146. *D. paniculatum*, very common; 2044. *Lespedeza repens*, very common; 2064, 2076. *L. virginica*, restricted to the south old field; 2061. *L. intermedia*, common; 2063. *L. hirta*, common; 1556. *L. striata*, common around Headquarters and in the south old field; 2085. *L. stipulacea*, a few at Headquarters; 2238. *Stylosanthes biflora* (typical), uncommon; 1946. *Vicia* sp., a small colony of sterile plants in the north old field; 2265. *Apios americana*, fairly common; 1329. *Clitoria mariana*, fairly common; 1948, 2058. *Amphicarpa bracteata* (typical), fairly common; 1558.

Linaceae.—Linum virginanum, fairly common; 1263, 2043.

Oxalidaceae.—Oxalis violacea, fairly common; the specimen approaches var. *trichophora*; 1071. *O. corniculata*, apparently restricted to the south old field; 2182. *O. europaea*, uncommon; 1869. *O. grandis*, uncommon; 1151.

Geraniaceae.—Geranium maculatum, common; 1042.

Polygalaceae.—Polygala incarnata, occasional; 1276, 1562. *P. sanguinea*, a few in the north old field; 1341. *P. verticillata* var. *ambigua*, common; 1354, 1564, 2073.

Euphorbiaceae.—Acalypha gracilens, common; 1640. *Euphorbia corollata*, very common; variable in amount of pubescence; 1266, 1563, 1883. *E. supina*, only on roadsides in the south old field; 2186, 2226. *E. maculata*, occasional; 2181.

Callitrichaceae.—Callitriche deflexa var. *austini*, common around ruts and puddles and on other damp, bare soil; 1897.

Anacardiaceae.—Rhus typhina, a solitary tree on Yellow-jacket Ridge; 1902. *R. glabra* (typical), common; 1265. *R. copallina* var. *latifolia*, very common; 2067. *R. aromatica* (typical), a few at base of the Watch Rocks; 1298. *R. radicans*, very common; 2245.

Aquifoliaceae.—Ilex verticillata var. *padifolia*, occasional; 1290.

Celastraceae.—Euonymus atropurpureus, uncommon; 1152, 1663. *Celastrus scandens*, fairly common; 2157.

Staphyleaceae.—Staphylea trifolia, uncommon; 1120.

Aceraceae.—Acer saccharum, common; 2204. *A. nigrum*, occasional 2203. *A. rubrum* (typical), common; 1173. *A. saccharinum*, fairly common; 1812.

Hippocastanaceae.—Aesculus octandra, fairly common; 1813.

Balsaminaceae.—Impatiens pallida, very common; 1621. *I. capensis*, very common; 1622.

Rhamnaceae.—Ceanothus americanus, very common; 1135, 1346.

Vitaceae.—Parthenocissus quinquefolia, fairly common; 1850. *Vitis aestivalis* var. *argentifolia*, common; 2200, 2220. *V. riparia* (typical), fairly common; 2235.

Tiliaceae.—Tilia americana (including *T. neglecta*), fairly common; 2161.

Malvaceae.—Sida spinosa, chiefly on roadsides in the south old field; 2071. *Abutilon theophrasti*, a few along road in the south old field; 2183.

Guttiferae.—Hypericum perforatum, recently collected on a roadside in the south old field; specimen not yet deposited. *H. punctatum*, common; 1270, 1344. *H. spathulatum*, chiefly in the north old field, occasional elsewhere; 1391. *H. mutilum*, fairly common; 1463. *H. gentianoides*, only in the south old field; 2195.

Cistaceae.—Lechea racemulosa, common; 2075.

Violaceae.—Hybanthus concolor, uncommon; 1121. *Viola cucullata*, uncommon; 1818. *V. papilionacea*, common; 1092. *V. triloba* (typical), fairly common; 1044. *V. blanda*, fairly common; 1082, 1809. *V. canadensis*, common; 1057, 1081. *V. striata*, fairly common; 1118.

Passifloraceae.—Passiflora lutea, collected recently in upland woods near Headquarters; specimen not yet deposited.

Nyssaceae.—Nyssa sylvatica var. *caroliniana*, common; 1193.

Onagraceae.—Ludwigia alternifolia, fairly common; 1353, 2077. *L. palustris* var. *americana*,

occasional; 1628. *Epilobium coloratum*, occasional; 2057, 2240. *Oenothera biennis*, uncommon; 1983. *O. pilosella*, a few in the north old field; 1278. *Circaea quadrisulcata* var. *canadensis*, fairly common; 1323.

Araliaceae.—Aralia racemosa, a few on a steep slope along Elk Fork; 1393. *A. nudicaulis*, several individuals at head of a moist ravine; 1155. *Panax quinquefolius*, occasional; 1399.

Umbelliferae.—Sanicula canadensis, common; 1272, 1935. *Osmorhiza claytoni*, uncommon; 1394. *O. longistylis* (typical), fairly common; 1119. *Erigenia bulbosa*, occasional; 1707. *Zizia aptera*, common; 1070, 1169. *Cicuta maculata* (typical), uncommon; 1841. *Cryptotaenia canadensis*, common; 1840. *Taenidia integerrima*, occasional; 1162. *Thaspium barbinode*, one colony on a terrace along Elk Fork; 1295. *Angelica venenosa*, uncommon; 1437, 1990. *Daucus carota*, fairly common; 1386.

Cornaceae.—Cornus florida, very common; 1045. *C. obliqua*, fairly common; 1287. *C. alternifolia*, occasional; 1382.

Pyrolaceae.—Chimaphila maculata, fairly common; 1359. *Pyrola rotundifolia* var. *americana*, uncommon; 1851. *Monotropa uniflora*, fairly common; 1379, 1457. *M. hypopithys*, fairly common; 1460.

Ericaceae.—Rhododendron roseum, one colony; 1106, 1814. *Kalmia latifolia*, very common; 1136. *Oxydendrum arboreum*, common; 1347. *Epigaea repens* (typical), common; 1047, 1702. *Gaultheria procumbens*, fairly common; 1464. *Gaylussacia baccata*, fairly common; 1191, 1815. *Vaccinium stamineum* (typical), common; 1068. *V. vacillans* (typical), very common; 1086.

Primulaceae.—Lysimachia quadrifolia, common; 1165. *L. ciliata*, common; 1331.

Ebenaceae.—Diospyros virginiana, uncommon; 2066.

Oleaceae.—Fraxinus americana (typical), fairly common; 2261. *F. pennsylvanica* (typical), a few saplings along Elk Fork; 2259. *Chionanthus virginicus*, a number of individuals on a moist ridgetop; 1104.

Gentianaceae.—Sabatia angularis, common; 1454. *Gentiana andrewsii*, a few along edge of the north old field; 1666. *Obolaria virginica*, a few on a rich north slope of Yellow-jacket Ridge; 1139.

Apocynaceae.—Apocynum androsaemifolium, uncommon; 1134. *A. cannabinum* var. *pubescens*, fairly common; 1131.

Asclepiadaceae.—Asclepias tuberosa, uncommon; 1348. *A. quadrifolia*, fairly common; 1108. *A. exaltata*, occasional; 1291. *A. variegata*, uncommon; 1179. *A. syriaca*, a single sterile individual at Headquarters; 2239. *A. hirtella*, a number in the south old field; 1401, 1890.

Convolvulaceae.—Ipomoea purpurea, a few on a roadside in the south old field; 2189. *I. pandurata*, uncommon; 1944. *Convolvulus spithamaeus*, collected once on a roadside bank near Headquarters; 1171. *Cuscuta gronovii*, common; 1623, 2050.

Polemoniaceae.—Polemonium reptans, common; 1055. *Phlox subulata*, common; our material variable in amount of glandularity; 1003, 1087, 1751. *P. divaricata*, common; 1056. *P. pilosa*, collected once in oak woods near Headquarters; 1103. *P. stolonifera*, a large colony in a hemlock stand along Elk Fork and small patches in a rich ravine; 1810. *P. maculata* var. *purpurea*, uncommon along Pine Run; 1975. *P. paniculata*, fairly common; 1443.

Hydrophyllaceae.—Hydrophyllum macrophyllum, uncommon; 1154. *H. canadense*, uncommon; 1852.

Boraginaceae.—Cynoglossum virginianum, fairly common; 1141. *Myosotis verna*, occasional; 1078. *Mertensia virginica*, uncommon; 1708, 1749.

Verbenaceae.—Verbena urticifolia, uncommon; 1351.

Labiatae.—Trichostema dichotomum, chiefly in the south old field; 2193. *Teucrium canadense* var. *virginicum*, no specimens. *Scutellaria serrata*, fairly common; 1143. *S. incana*, uncommon; 1455, 2246. *S. lateriflora*, fairly common; 1626, 1981. *S. nervosa* (typical), uncommon; 1150. *Meehania cordata*, scattered colonies on rich lower slopes along Elk Fork; 1296. *Glechoma hederacea* var. *micrantha*, fairly common; 1089. *Prunella vulgaris* var. *lanceolata*, fairly common; 1342. *Stachys riddellii*, uncommon; 1384, 1842. *Salvia lyrata*, occasional along Pine Run; 1843. *Monarda clinopodia*, fairly common; 1283. *M. fistulosa* (typical), occasional; 1378. *Blephilia hirsuta*, occasional; 1383. *Hedeoma pulegioides*, very common; 1451. *Pycnanthemum tenuifolium*, common; 1339. *P. incanum*, occasional; 1377. *Cunila origanoides*, very common;

1611. *Lycopus virginicus*, fairly common; 1988, 2173. *Collinsonia canadensis*, common; 1629, 2049.

Solanaceae.—Solanum americanum, uncommon; 1552, 2223. *S. carolinense*, occasional; 1352. *Physalis virginiana*, collected once on a hillside along Pine Run; 2247.

Scrophulariaceae.—Verbascum thapsus, fairly common; 1895. *Chelone glabra* var. *elatior*, fairly common; 1620. *Penstemon digitalis*, restricted to the south old field; 2060 *Mimulus ringens*, common; 1984. *M. alatus*, collected once on a mudflat along Elk Fork; 2081. *Gratiola neglecta*, scattered colonies about moist depressions in roads; 1274A; 2054. *Veronicastrum virginicum*, uncommon; 1446. *Veronica serpyllifolia*, a few at Headquarters; 1873. *V. peregrina* (typical), a few at Headquarters; 1817. *V. arvensis*, a few at Headquarters; 1788. *Gerardia tenuifolia* (typical), common; 1609, 2138. *G. laevigata*, common; 1438. *G. flava* var. *macrantha*, fairly common; 1555. *Pedicularis canadensis* (typical), fairly common; 1125, 1806.

Orobanchaceae.—Epifagus virginiana, occasional; 2088. *Conopholis americana*, occasional; 1122. *Orobanche uniflora*, collected once; 1807.

Acanthaceae.—Justicia americana, occasional along Elk Fork; 1362.

Phrymaceae.—Phryma leptostachya, one colony; 1371.

Plantaginaceae.—Plantago rugelii, chiefly at Headquarters; 1874. *P. lanceolata* (typical), occasional; 1794.

Rubiaceae.—Galium aparine, uncommon; 1090. *G. triflorum*, occasional; 2234. *G. pilosum*, occasional; 1373. *G. circaezans*, common; 1267. *G. lanceolatum*, uncommon; 1172. *G. tinctorium*, occasional along Pine Run; 1325. *G. concinnum*, common; 2251. *G. asprellum*, common along Pine Run; 1625. *Mitchella repens*, uncommon; 1638. *Cephalanthus occidentalis* (typical), fairly common; 2171. *Houstonia caerulea*, very common; 1048, 1088. *H. longifolia*, very common; 1168, 1275.

Caprifoliaceae.—Triosteum perfoliatum, one small colony; 1635. *T. aurantiacum*, uncommon; 1811. *Viburnum cassinoides*, uncommon; 2180. *V. prunifolium*, common; 1114. *V. dentatum* (typical), fairly common; 1281. *V. acerifolium*, common; 1102. *Sambucus canadensis*, common; 1285.

Valerianaceae.—Valeriana pauciflora, fairly common; 1117. *Valerianella chenopodifolia*, uncommon; 1091, 1808.

Campanulaceae.—Specularia perfoliata, fairly common; 1105, 1397. *Campanula americana* var. *illinoensis*, uncommon; 1380. *Lobelia cardinalis*, fairly common; 1442. *L. siphilitica*, fairly common; 1619. *L. puberula* var. *simulans*, fairly common; 1608. *L. spicata* (typical), uncommon; 1358. *L. inflata*, very common; 1355, 1937.

Compositae.—Vernonia altissima, fairly common; 1614. *Eupatorium fistulosum*, common; 1616. *E. purpureum*, uncommon; 1554. *E. sessilifolium* (typical), common; 1440, 1993. *E. perfoliatum*, uncommon; 2168. *E. rugosum*, common; 1634. *E. coelestinum*, one small colony on a moist roadside; 2031. *Liatris scariosa*, fairly common; 1559. *Chrysopsis mariana*, uncommon; 1612. *Solidago caesia*, common; 1605, 2150. *S. flexicaulis*, common; 1665, 2178. *S. squarrosa*, a few on a rich slope along Elk Fork; 2163. *S. bicolor*, common; 1606. *S. erecta*, fairly common; 1439, 2046. *S. juncea*, very common; 1392. *S. patula* (typical), uncommon; 1613. *S. nemoralis*, common; 1565. *S. ulmifolia*, fairly common; 2218. *S. rugosa*, fairly common; 1617. *S. altissima*, uncommon; 2194, 2242. *S. graminifolia*, occasional, chiefly south old field; 2243. *Aster divaricatus*, common; 1630, 1659. *A. macrophyllus*, common; 1449, 2090. *A. shortii*, uncommon; 1664. *A. cordifolius* (typical), fairly common; 2162. *A. undulatus*, common; 1658, 2213, 2260. *A. patens* var. *phlogifolius*, fairly common; 2140, 2147. *A. prenanthoides*, fairly common; 2176, 2236. *A. puniceus* (typical), uncommon; 2169. *A. laevis*, uncommon; 2136. *A. pilosus* (typical), fairly common; 2214. *A. vimineus* (typical), uncommon; 2148. *A. lateriflorus*, fairly common; 1657, 2205. *A. infirmus*, occasional; 1991. *A. linariifolius*, one large colony; 1656. *Erigeron pulchellus*, occasional; 1126. *E. philadelphicus*, occasional around Headquarters; 1787. *E. annuus*, common; 1164. *E. canadensis*, common; 2033. *Sericocarpus asteroides*, very common; 1318, 1388. *Antennaria plantaginifolia*, very common; 1043. *Gnaphalium obtusifolium* (typical), fairly common; 1561. *G. purpureum*, uncommon; 1358A. *Ambrosia artemisiifolia* var. *elatior*, common; 1550, 2056. *Polymnia uvedalia*, one small colony; 1943. *Silphium perfoliatum*, fairly common; 1445 *S. trifoliatum* (typical), fairly common;

1345. *Heliopsis helianthoides*, a colony on Yellow-jacket Ridge; 1357. *Rudbeckia laciniata*, common; 1444. *R. hirta*, fairly common; 1194, 1264. *Helianthus divaricatus*, common; 1321, 1879. *H. hirsutus* (typical), fairly common; 2151. *H. microcephalus*, uncommon; 1938. *H. strumosus*, occasional; 2036. *Actinomeris alternifolia*, very common; 1615. *Coreopsis tripteris* (typical), fairly common; 1557. *Bidens frondosa*, fairly common; 2078. *Achillea millefolium*, fairly common; 1192. *Anthemis cotula*, a few at Headquarters; 1867. *Chrysanthemum leucanthemum* var. *pinnatifidum*, fairly common; 1340. *Erechtites hieracifolia*, common; 1607, 2152. *Cacalia suaveolens*, a colony along Elk Fork; 2089. *C. atriplicifolia*, fairly common; 1633. *Senecio aureus* var. *intercursus*, fairly common; 1111. *Cirsium altissimum*, fairly common; 1632. *Krigia biflora*, uncommon; 1124. *Taraxacum officinale*, only at Headquarters; 1865. *Lactuca canadensis*, common; our material very variable and assignable to several of the varieties recognized by Fernald; 1891, 1892, 2153. *Prenanthes serpentaria*, common; 1637. *P. altissima*, fairly common; 2177, 2221. *Hieracium vemosum* var. *nudicaule*, common; 1069. *H. paniculatum*, uncommon; 1610. *H. scabrum*, common; 1989. *H. gronovii*, only in the south old field; 2059.

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Dr. Carleton R. Ball determined the specimens of *Salix* and Dr. Carroll E. Wood, Jr., an unusually depauperate *Specularia*.

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NOTES ON THE ANTHONOMINAE

(COLEOPTERA, CURCULIONIDAE)

19. A contribution to the knowledge of the Curculionoidea

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While I was working on a revision of the Myrmecinae, several closely related species of the genus *Anthonomus* Germar, which superficially resemble the Myrmecinae, have come to my attention. They constitute the *funereus* and *albolineatus* groups of the Biologia Centrali-Americana and include the North American *albopilosus* Dietz.

They are members of *Anthonomus* (s. str.) having the scrobes directed against the eye; antennal funicle 7-segmented; antennal club not loosely articulate; elytra non-tuberculate; form oblong to obovate, very black and shining and for the most part resembling the genus *Myrmex* Strum.

Included in the paper are *Anthonomus funereus* Champ., *aterrimus* Champ., *otidocephaloides* Champ., *albopilosus* Dietz, *incanus* Champ., *albolineatus* Champ., *canescens* Champ., and two new species, both closely related to *funereus*.

Measurements of length are taken from a lateral view. Total length measured from front edge of eyes to apex of elytra. Other measurements are at widest or longest part of structure, with the exception of the rostrum, which is measured on the chord of the arc, from anterior margin of eyes to apex, excluding mandibles.

Localities given are for known records for the species or those of the material examined.

Key to the species treated:

1. Elytra nearly bare of vestiture except for setae around the margins and along the suture, the enclosed area very shining 2
1′. Elytra uniformly clothed with white setae or with the white setae condensed in patches, or stripes on the intervals 6
2. Anterior femora bidentate ..... *aterrimus* Champion
2′. Anterior femora unidentate 3
3. Sutural interval, at least for a short distance behind the scutellum, with closely placed white setae 4
3′. Sutural interval without a patch or band of closely placed setae behind the scutellum or at any other place on the sutural interval ..... *otidocephaloides* Champion
4. Punctures on pronotum fine, separated by twice or more their own diameter; a few scattered setae present in the rather bare area on the elytra, many of the elytral intervals clothed with a single row of inconspicuous, fine, black, recurved setae. Venezuela .... *parafunereus*, new species
4′. Punctures of pronotum coarser, not so widely separated; white setae apparently absent from bare area of the elytra, except in the extreme apical region 5
5. Rostrum longer, more slender, two-thirds longer than prothorax (1.666:1); fore femora longer, more slender (length to width-4.200:1); fore tibiae of ♂ bent in basad third, long and slender (length to width-8:1); pronotal punctures moderately coarse, separated by approximately their diameter; striae of elytra feebly impressed. (Panama, Nicaragua) *funereus* Champion
5′. Rostrum shorter, more robust, two-fifths longer than prothorax (1.416:1); fore femora shorter, more robust (length to width-3.333:1); fore tibiae of ♂ not noticeably bent in basad third, shorter, more robust (length to width-5.833:1); pronotal punctures very coarse, separated by half or less their diameter; elytral striae strongly impressed. Mexico ..... *veracruzensis*, new species

6. Elytra rather sparsely and uniformly clothed with white setae none of which are condensed in patches or lines on the elytra; male with a small tooth on the inner edge of the hind tibia near the apex ..... *albopilosus* Dietz
6′. Not as above 7
7. Elytral vestiture finer, rather uniform, not condensed in lines or patches, except occasionally in a small spot immediately behind the scutellum ..... *incanus* Champion
7′. Elytral vestiture coarse, condensed in lines and/or patches, a prominent line behind scutellum frequently extending to apex 8
8. Elytral vestiture arranged in interupted lines on the elytra, becoming evanescent on the disc anteriorly; prothorax coarsely, rather sparsely punctured ..... *albolineatus* Champion
8′. Elytral vestiture serially arranged on each of the intervals, extending up the intervals to the base; prothorax coarsely, closely punctured ..... *canescens* Champion

Anthonomus aterrimus Champion

Anthonomus aterrimus Champion 1903, p. 167.

Panama: Bugaba, Volcan de Chiriqui (Champion); San Margarita, C. Z., V–15–46, ELS. Three examples have been studied, none varying notably from the original description.

Anthonomus otidocephaloides Champion

Anthonomus otidocephaloides Champion 1906, p. 722.

Panama: Bugaba (Champion); Puerto Bello, V–20–46, ELS, (ELS).

Only the example collected by the author has been examined. This specimen fits the original description so perfectly that there can be no doubt as to its identity. This species is deceptively like the smaller species of *Myrmex* in general facies.

Anthonomus paráfunereus, new species

Female. Elongate-oblong; very shining black with antennal scape reddish brown, funicle and club darker; head, sides, base and middle line of prothorax, scutellum, first elytral interval and apical margin of elytra sparsely clothed with short recurved white setae, first elytral interval a short distance behind scutellum and metepisterna densely clothed with similar setae, the bare, shining part of the elytra with a few scattered setae, most intervals with a single row of very fine, inconspicuous black setae. *Rostrum* nearly twice as long as prothorax (13.2:7), slender, moderately arcuate, finely, sparsely punctured in the basal half, smooth and shining in the apical half with a few minute, scattered punctures, a deep sulcus in the basal third above each antennal scrobe. Antennae inserted just before middle, scape attaining eye; funicle long and slender, first two segments elongate, the first more robust, nearly one-third longer than second, second twice as long as third, third and fourth subequal, fifth a little shorter, the fifth, sixth and seventh nearly subequal (3:2.2:1:1:.8:.9:.8); club elongate, almost as long as the preceding five combined. *Head* smooth, with a few scattered minute punctures, front flattened, with a very small, deep, foviform puncture; eyes moderately convex, coarsely granulated, separated on front, at nearest point, by one-half the width of the rostrum at base. *Prothorax* slightly wider than long (7.5:7), base more than one-third wider than apex, strongly convex dorsally, sides strongly rounded, constricted at apex, margined along basal edge; pronotum finely, sparsely punctured, the punctures separated from one and one-half to twice their diameter, a little coarser and closer on sides. *Elytra* elongate, one-half longer than wide (16.2:10.4), one and three-eighths (16.2:7) longer than the prothorax, sharply margined basally; humeri rather prominent; sides slightly divergent from humeri to middle, then strongly convergent to apex; striae not impressed except the first which is feebly impressed just behind the scutellum; strial punctures small, rounded, deep, separated by one and one-half to two times their diameter; intervals flat. *Ventral side* sparsely clothed with recumbent white setae which are denser and more squamiform laterally. Prosternum very short in front of fore coxae. Metasternum and abdominal sternites 1–4 strongly alutaceous; fifth sternite moderately deeply punctured, shorter than preceding two combined. Anterior femora more robust, more strongly clavate than others, anterior femoral tooth large and acute, remaining, small and acute. All tibiae strongly sinuate at middle. Tarsal claws with a long slender tooth. Length 4.5 mm., width 1.75 mm.

Male. Unknown.

Type loaclity. Akuiman, Venezuela.

Type material. Holotype (#69), ♀, 1 ♀ paratype (ELS), 3 ♀ ♀ paratypes (D. G. Kissinger Collection), all from Akuiman, Venezuela, 1940, P. Anduze Collr.; 1 ♀ paratype, Paraitepuy, Venezuela, XII-16-40, P. Anduze, (ELS). Length of paratypes 3.0–5.0 mm., width 1.4-2.0 mm.

This species is most closely related to, but quickly separated from, *A. funereus* Champion of Central America, differing in the finer pronotal and strial punctures; the non impressed elytral striae and the absence of reddish basad areas of the femora.

Anthonomus funereus Champion

Anthonomus funereus Champion 1903, p. 166. (In part).

Panama: Bugaba (Champion); *Nicaragua*: Chontales (Belt).

A rather knotty problem has arisen regarding the type of *funereus*. J. Balfour Browne informs me that "This specimen figured (Pl. 10, fig. 1, 1a, b.) is from Mexico: Toxpam (Salle). This specimen bears the British Museum type label." The specimen bearing the type label cannot be accepted as the holotype, since Champion states (p. 166) "Five specimens, the two from Mexico belonging to the variety." I have examined a male from Bugaba, Panama which Champion had at hand at the time he drew up the descriptions. It is designated as lectotype to replace the specimen wrongly labeled type in the British Museum (Natural History) Collection.

I have examined one of the two examples belonging to the "variety" mentioned by Champion from Toxpam, Mexico and find it to be *veracruzensis*, new species. It is not a "variety" of *funereus* differing as pointed out in the key and elsewhere in this paper.

A number of errors in Champion's original description of *funereus* have been found. I have taken the liberty of modifying and adding more to his original description.

Elongate-ovate, very shining, black, the antennal scape, and usually the base of the femora also, ferruginous; the head, the sides, base, and middle of the prothorax, the apical declivity of the elytra, the under surface, and legs with long and sparse, a line along the suture of the elytra at base, extending on to the scutellum, another along their apical margin, and the sternal side-pieces, with dense, white pubescence. *Head* sparsely punctured, the interocular space smooth, in some specimens, deeply foveate above eyes, the latter large and separated at nearest point on front by three-fifths the width of the rostrum at base. *Rostrum* (♂) about two-thirds longer than prothorax (1.666:1), moderately curved, seriate-punctate, sparsely punctured apically, (♀) longer and smoother, the antennae inserted near the middle in the ♀ and at about one-third or two-fifths from apex in the ♂. Antennae with first funicular segment nearly as long as following two combined, second one-half longer than third, 3–5 equal, 6–7 equal, slightly shorter than each of the preceding (2.25:1.5:1.:1.:1.:.8:.8);club elongate, nearly as long as the preceding four combined. *Prothorax* a little broader than long (7:6), transversely convex, rounded at the sides, narrowed and constricted in front, moderately coarsely punctured, on pronotum separated by about their diameter, closer on sides. *Elytra* oblong, two-thirds longer than wide (15:9), gibbous, compressed at sides, sloping towards the base, which is sharply margined, not much wider than prothorax; humeri a little swollen; suture depressed in front; striae finely punctured, the punctures oblong, separated for the most part by their diameter; intervals flat and smooth. Legs long; anterior femora strongly clavate and with a stout triangular tooth, middle and hind femora with an acute tooth; front and middle tibiae strongly sinuate, hind tibiae slender, same width throughout; fore tibiae of ♂ strongly curved in basal third. Tarsal claws with a long tooth. Length 3.5–4.0 mm., width 1.5–1.75 mm. (Lectotype, length 3.8 mm., width 1.6 mm.)

Anthonomus veracruzensis, new species

Anthonomus funereus var. Champion 1903, p. 166, and Tab. X. (fig. 1, 1a, b, ♂.)

Male. Elongate-oblong; very shining, black with antennae and base of femora reddish brown; head, sides, base and middle line of prothorax, scutellum, the first elytral interval, and apical margin of elytra and legs clothed with coarse white recumbent setae. *Rostrum* nearly one-half longer (8.5:6) than prothorax, slightly curved, closely, evenly punctured basad of antennal insertion, sparser and finer apically. Antennae inserted one-third from apex; funicle with first

and second segment elongate, first more robust, densely clothed with long setae, one third longer than second, second nearly twice as long as third, third and fourth subequal, each slightly longer than fifth or sixth, seventh a little longer (2.5:1.9:1.:1.:.8:.8:1); club elongate, longer than the preceding four combined. *Head* closely, coarsely punctured; the front with a deep punctiform fovea; eyes prominent, convex, coarsely granulated, separated at nearest point on front by three-fifths the width of the rostrum at base. *Prothorax* one-sixth wider than long (7:6), base about one-thrd wider than apex, sides strongly rounded, strongly constricted apically, pronotum and flanks very closely, deeply punctured, separated by less than one-fourth their diameter. Scutellum rounded. *Elytra* elongate, three-fifths longer than wide (14:9), strongly margined basally; humeri rectangular, prominent; the sides slightly divergent to beyond middle, then strongly convergent to apex; striae feebly impressed, except the sutural striae adjacent and immediately behind scutellum; strial punctures fine, elongate, not deeply impressed, separated by about their length; intervals flat, very minutely punctulate. *Ventral side* with prosternum rather densely clothed with long white setae, meso-, metasternum, and abdominal sternites rather sparsely clothed with short, clavate, scale-like setae, the metepisterna densely clothed with similar scale-like setae. Metasternum finely punctured laterally, finely transversely rugulose at middle. Abdominal sternites rather closely punctured; the first and second slightly flattened and densely punctured at middle; fifth sternite truncated apically, and with a dense patch of setae at middle. Pygidium very closely, finely punctured, feebly concave in apical half, apical margin raised into a sharp carina. Fore femora more robust than the others, armed with a large acute tooth. Teeth very small on middle and hind femora, being nearly absent on the hind pair. Fore and middle tibiae feebly sinuate, the hind ones not at all sinuate. Tarsal claws with a long slender tooth. Length 3.7 mm., width 1.5 mm.

Female. Differs from the ♂ only slightly, having the first and second abdominal sternites more strongly convex, the fifth sternite not truncate, but rounded apically and lacking the patch of setae at middle.

Type locality. Cordoba, Vera Cruz, Mexico.

Type material. Holotype (#70), ♂, from type locality, III–1–46, ELS, (ELS). Allotype, Toxpam, Mexico, Sallé collr., (*funereus* var. Champion), Entomological Collection, British Museum (Natural History).

Nearest *funereus* Champion, but differs in that *veracruzensis* has the rostrum shorter, more robust and more strongly curved, the legs are shorter and robust (see accompanying chart), pronotum more densely, coarsely punctured, and the smaller femoral teeth.

	parafunereus	*funereus*	*veracruzensis*
Length of rostrum-prothorax	1.886:1	1.667:1	1.417:1
Fore femora Length-width	4.286:1	4.200:1	3.333:1
Fore tibia Length-width	6.667:1	8:1	5.833:1

Anthonomus albopilosus Dietz

Anthonomus albopilosus Dietz 1891, p. 222.

United States, *Arizona*: Bisbee, Tombstone, and Nogales; *Arkansas*: Fayetteville, VII/X–13–26, D. Isley, (U. Arkansas, ELS); *California*: Araz and El Centro; *Mississippi*: Richton, IX–16–31, H. Dietrich, (Cornell U., ELS); *New Mexico*: Santa Fe, VIII–5–49, (USNM), Las Cruces, Silver City, and San Marical; *Texas*: Angletown, V–13–44, Fraser & Harrison, (USNM), Brownsville, Radford, Mission, Presidio, Marfa. *Mexico*, *Sonora*: Cananea and Fronteras, (ELS); *Chichuahua*: Guadalupe, (ELS).

Anthonomus incanus Champion

Anthonomus incanus Champion 1903, p. 168.

Mexico: Mazatlan, Ventanas, Colima City (Höge), Cuernevaca (Smith).

No examples of this species were recognized in the material at hand. The Mazatlan record is rather indefinite in as much as there are several localities known as Mazatlan in Mexico.

Anthonomus albolineatus Champion

Anthonomus albolineatus Champion 1903, p. 167.

Mexico, Vera Cruz: Orizaba, Sallé collr., (examined), Catemeco, Coyame, VI-54, DGK, (ELS), Cordoba. *Guatemala, Vera Paz*: Cubilguitz, Champion collr.

Three of the four examples examined fit the original description very well. The fourth example, a diminutive female, from 10 miles N.E. of Mogone, Oaxaca, Mexico (at the fork in the Rio Coatzocoalcos), III–14–46, ELS, (ELS), is tentatively placed here.

Anthonomus canescens Champion

Anthonomus canescens Champion 1903, p. 168.

Mexico, Guerrero: Acapulco, Höge collr.

No examples of this species were recognized in the material at hand.

ACKNOWLEDGEMENTS

I am indeed grateful to Dr. Fred Truxal and the Los Angeles County Museum for making otherwise unobtainable literature available, and to Mr. J. Balfour-Browne, British Museum (Natural History), for efforts on his part in aiding to properly place the material and for pertinent information regarding the types.

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Dietz, W. G. 1891. Revision of the genera and species of the Anthonomini inhabiting North America. Trans. Amer. Ent. Soc. 18: 177–276.

Block Diagrams. *A. K. Lobeck.* Emerson-Trussell Book Company, Amherst, Massachusetts. Second Edition, 1958. xii+212 pp. $6.00.

This excellent and valuable book of instructions for drawing of landscapes, geologic structures, geologic block diagrams, and crystals has been slightly revised and reissued after 34 years. For many of these years it has been out of print. The original text intentionally has not been altered. Some new illustrative material has been inserted on what were blank spaces at the ends of chapters in the first edition; thus the pagination has not been altered, nor has the index. Pages 207 through 212, describing and illustrating the techniques of field sketching and sketching from photographs, have been added at the end of the book. This treatment of sketching is the only change of any consequence from the first edition, and is supplementary to material that was already in the body of the text. Nevertheless, the publishers are to be thanked for making this helpful book available to a new and larger generation of earth scientists.

MALCOLM P. WEISS

Mysteries of Science, A Study of the Limintations of the Scientific Method. *John Rowland* Philosophical Library, Inc., New York, 1957. 4 $6.00.

The author attempts to indicate certain questions (mysteries) which are supposedly inadequately answered by science. Examples are chosen among physics, biology, psychology and sociology, principally, but also certain "unclassifiable" subjects which include "flying saucers" and dowsing (water witching). Although references to works of questionable veracity are cited on "flying saucers," no discussions on dowsing are mentioned—some of which do an excellent job of debunking.

Patience Worth and Sally Beauchamp are given considerable space in the chapter on psychology. Unfortunately no comparison is sought between these chronologically remote cases and the recent nonsense involved in *The Search for Bridey Murphy*.

Most scientists probably will agree that knowledge is imperfect and incomplete on any subject, and many are mindful of the value of metaphysical concepts, nevertheless, they will receive little inspiration from this book. The author makes merely a desultory effort to distinguish between his "facts" and what is probably fiction.

DUNCAN MCCONNELL

ATMOSPHERIC POLLEN AND SPORE STUDIES AT COLUMBUS, OHIO DURING 1957[1]

N. N. WILLIAMS AND G. E. GILBERT

Department of Botany and Plant Pathology, Ohio State University, Columbus 10

During a previous investigation largely concerning atmospheric ragweed pollen (*Ambrosia* spp.) in the Columbus, Ohio, area, it became apparent that a relatively complex annual incidence of pollen and spores occurred in the local atmosphere (Gilbert, 1950). It was hoped at that time that a study could soon be made concerning the annual incidence of these items, and such an opportunity arose early in 1957 through the cooperation of allergists of the Division of Allergy, Ohio State University Department of Medicine, whose financial contributions to The Ohio State University Development Fund enabled this study.

METHODS

Pollen and spore counts were made by the standard gravity slide method recommended by the Committee on the Standardization of Pollen Counting Techniques of the American Academy of Allergy (1946). A standard sampling device was mounted approximately five ft above the roof of the Botany and Zoology building, and slides coated with a petrolatum jelly-mineral oil mixture were exposed for a period of 24 hr, beginning at 0800 E.S.T. ± one hr.

Slides were prepared for observation by staining with a mixture of 50 cm^3 glycerine, 100 cm^3 70 percent alcohol, and 2 drops of a saturated aqueous solution of safranin 0. A 22 x 50 mm cover slip was applied, and pollen grains and spores within an area of 2.5 cm^2 were counted.

Exposure of slides was begun on February 15, 1957, and the initial counts concerned pollen grains only. The counting of spores was initiated on April 21.

RESULTS

The results in number of pollen grains and spores per cm^2/day are graphically presented in figures 1, 2, and 3. A number of additional types of pollen grains were collected; however, since their deposition rarely exceeded five gr/cm^2, they are not graphically presented. Spores other than *Alternaria* spp. were not differentiated in the counting because of the great difficulties encountered in rapid identification.

DISCUSSION

1. The maximum daily collection of a given type of pollen was that of *Populus* and was 1510 pollen gr/cm^2. A number of relatively large cottonwood trees occur in the near vicinity of the Botany and Zoology building. The maximum collection of *Populus* grains occurred on April 21, a day characterized by clear skies, relatively high temperatures, and light wind. Appreciable amounts of *Populus* pollen were collected over a period lasting only six days.

2. Maximum collection of spores, including *Alternaria*, was on September 3, and was 1637 spores/cm^2.

3. The local ragweed pollen season began during the first week of August and appears to have reached its peak during the first week of September, following which the incidence markedly diminished, and by October 1 few such pollen grains were in the local atmosphere. However, as early as the latter part of June,

[1]Publication 623, Department of Botany and Plant Pathology, The Ohio State University.

occasional appreciable quantities of apparently fresh ragweed pollen were collected, and are believed to indicate pollen transport into the local atmosphere from distant areas by southerly winds. Also, sporadic collection of a few, evidently old, ragweed pollen grains occurred on gusty days throughout the winter, spring, and summer seasons.

4. The maximum collection of *Ulmus* pollen occurred on March 24, and was 775 gr cm². On the following day, a freezing rain occurred during the morning hours, and a cold front passage accompanied by heavy showers occurred in the afternoon. This weather resulted in a clearing of the local atmosphere of pollen grains, not only of elm but of all other types of pollen grains in the atmosphere at that time, which included *Taxus*, *Acer*, *Juniperus*, and *Corylus*.

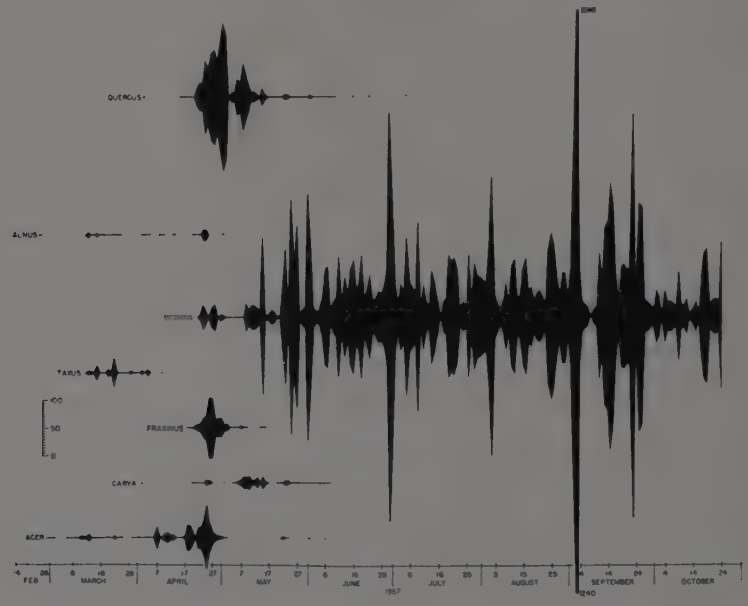

FIGURE 1. Atmospheric incidence of pollen grains and spores at Columbus, Ohio, during 1957, number per cm² of slide surface per day.

5. On the morning of May 2, a cold air mass entered the central Ohio area and persisted for several days. During this period relatively few pollen grains or spores were collected.

6. Twenty-eight types of pollen grains were sufficiently abundant in the local atmosphere during 1957 to result in a collection density equal to or greater than five pollen gr/cm²/day.

7. Scattered showers which occurred during the afternoon and evening of September 7 (near peak ragweed pollen season) cleared the local atmosphere of pollen grains to the extent that during the following day extremely few spores and only one pollen grain were on the 2.5 cm² of slide surface observed.

8. The first killing frosts occurred on October 11, 12, and 13, and appear to have had a direct effect upon the concentration of atmospheric *Alternaria* spores which diminished considerably during the period of the frost.

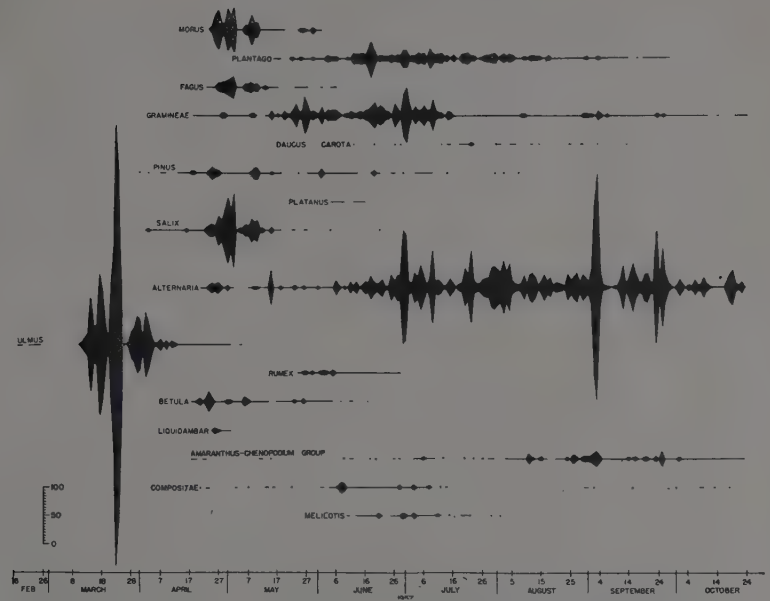

FIGURE 2. Atmospheric incidence of pollen grains and spores at Columbus, Ohio, during 1957, number per cm² of slide surface per day.

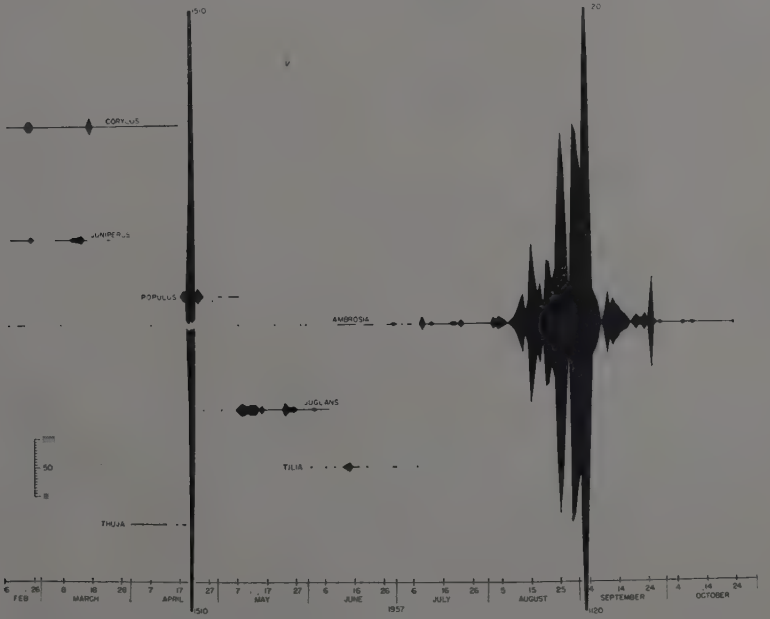

FIGURE 3. Atmospheric incidence of pollen grains and spores at Columbus, Ohio, during 1957, number per cm² of slide surface per day.

9. Additional types of pollen grains and spores collected during the course of investigation include: *Taraxacum* (Dandelion), *Magnolia* (Magnolia), *Tsuga* (Hemlock), *Aesculus* (Buckeye), *Picea* (Spruce), *Celtis* (Hackberry), *Carex* (Sedge), *Equisetum* (Horsetail), *Castanea* (Chestnut), *Urtica* (Nettle), *Ligustrum* (Privet), and *Typha* (Cat-tail). The source of Chestnut pollen was evidently one Chestnut tree present in the nearby Botanic Garden.

10. The biweekly distribution of the number of major types of pollen grains present in the local atmosphere during 1957 was as follows:

Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.	
1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0	5	6	9	10	21	18	18	19	14	10	7	7	6	6	6	5	4	3	1

ACKNOWLEDGMENTS

The authors are greatly indebted to the following individuals and institutions whose interest and cooperation made this study possible: allergists of the Division of Allergy, Ohio State University Department of Medicine, whose contributions enabled the senior author to devote the necessary time for pollen and spore counting; the Department of Botany and Plant Pathology which furnished all incidentals and equipment used in the research, and The Ohio State University Development Fund which administered the project.

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Gilbert, G. E. 1950. Volumetric and gravity slide tests for airborne ragweed and oak pollen grains at Columbus, Ohio. Ohio Jour. Sci. 50: 60–70.

X-Ray Crystal Structure. *Dan McLachlan, Jr.* McGraw-Hill Book Co., New York, 1957. xiii+416 pp. $15.00.

To this reviewer, McLachlan's book appears to be what has been sought as a textbook for a graduate course in which the laboratory exercises involve solution of crystallographic problems by x-ray diffraction methods. This book contains all of the fundamental theory essential to the solution of an original problem involving structure determination. Surprisingly, however, certain data (for example, *f* values) are omitted.

Following a discussion of the reciprocal lattice, the experimental methods are given in logical order, beginning with that of von Laue. Chapter 8 discusses the computational aids that are often used to handle the extremely tedious calculations. The appendix, "Special Recording Techniques," describes some tricky devices of very limited utility.

The author has done an outstanding service for the beginner, but the value of this work is by no means limited to the novice. The book is excellently illustrated with diagrams and halftones.

DUNCAN MCCONNELL

SOME ALGAE FROM THE OHIO RIVER DRAINAGE BASIN

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INTRODUCTION

Studies are being conducted at the Robert A. Taft Sanitary Engineering Center on the algae of importance in water supply, sewage treatment, and stream pollution. In the course of these studies, a number of algae of particular interest both in sanitary biology and as species records have been encountered in the Ohio River drainage basin. Some of the algae included in this paper are those which are little known or infrequently reported from this area and for which additional records would be useful. Others are reported because they have been found growing in unusual environmental situations. One such habitat was the trickling filters in the Fairmount Sewage Treatment Plant, Dayton, Ohio. A year-long study of the algal and fungal populations of these filters showed that algal growth was abundant on the surface slag rocks throughout the year (Cooke and Hirsch, 1958).

Other algae discussed in this paper were found during a recent study of the plankton and bottom algae of the Scioto River. In a previous study of the river, Kehr et al (1941) observed that the plankton organisms were far in excess of those of previously studied rivers, both in numbers of species and numbers of organisms present. The species discussed here are ones not reported from this previous study. Additional algae listed here were collected from Lytle Creek. The effects of organic pollution from the effluent of the Wilmington, Ohio, primary sewage treatment plant on the fauna of this small stream have been studied and reported (Gaufin and Tarzwell, 1952, 1955, and others). The activated sludge treatment process was added to the plant in 1954, and this has changed the nature of the effluent and thus of the habitat downstream since the algae were collected. Still other algae represent collections made from lakes, ponds, and streams and a sewage treatment plant on the Ohio river drainage basin.

Fourteen of the algae are listed primarily because they represent species in the region from which unialgal cultures have been obtained. These cultures are among those which have been used at the Center in experiments on potential algicides (Foter, et al, 1953; Palmer and Maloney, 1955; Maloney and Palmer, 1956; Maloney, 1958) and taste and odor research (Palmer, 1952, and Palmer and Maloney, 1953). Species which at present can be grown readily in culture tend to be those which are common inhabitants of the flora and are not very specific in their nutritional requirements. The cultures referred to were isolated from algae collected from natural waters in southeastern Ohio and from aquaria kept indoors at the Sanitary Engineering Center in Cincinnati.

THE OHIO JOURNAL OF SCIENCE 58(6): 375, November, 1958.

List of Algae

The algae referred to in this report are as follows:

Myxophyceae
Agmenellum thermale
Amphithrix janthina
Anacystis cyanea
Anacystis montana
Calothrix parietina
Fremyella diplosiphon
Gomphosphaeria wichurae
Hapalosiphon fontinalis
Oscillatoria curviceps
Oscillatoria princeps
Oscillatoria tenuis
Phormidium uncinatum
Plectonema nostocorum
Symploca erecta
Rhodophyceae
Audouinella leibeinii
Thorea andina
Chlorophyceae
Ankistrodesmus falcatus
Ankistrodesmus falcatus var. *acicularis*
Chlamydomonas communis
Chlamydomonas paradoxa
Chlorotylium mammiforme
Oocystis lacustris
Oocystis marssonii
Scenedesmus obliquus
Stigeoclonium nanum
Tetraspora gelatinosa
Ulothrix tenuissima
Euglenophyceae
Euglena mutabilis
Lepocinclis ovus
Xanthophyceae
Centritractus belonophorus
Bacillariophyceae
Achnanthes linearis
Biddulphia laevis
Cymbella microcephala
Gomphonema parvulum
Melosira crenulata var. *tenuis*
Nitzschia palea
Rhoicosphenia curvata

Herbarium specimens of all these algae except for *Euglena*, *Lepocinclis*, and *Centritractus* are on file in the collections of the Chicago Natural History Museum.

Information on Each Species

Agmenellum thermale (*Kütz.*) *Dr. and Daily. Figure 1.*—Big Sandy River, Catlettsburg, Boyd County, Kentucky. Collected by C. M. Palmer, September 25, 1955. Identification by F. Drouet. Mixed with *Oscillatoria curviceps* which formed a surface "bloom" in pool just above dam.

Amphithrix janthina (*Mont.*) *Born. and Flah.*—Fairmount Sewage Treatment Plant, Dayton, Montgomery County, Ohio. Collected by A. Hirsch and Wm. Bridge Cooke, November 21, 1955. Identification by F. Drouet. Found on trickling filters throughout the year, entangled among other algae. Generally forming small, dense, blue-green clumps. Drouet (written communication, February 7, 1956) describes this form as being ". . . with often curved and branched filaments instead of the upright and parallel filaments one reads of in the descriptions and sees in the illustrated manuals; this 'atypical' habit is characteristic of this species in habitats where other algae have overgrown it . . . the larger trichomes here have been distinguished by the name var. *torulosa* (Grun.) Born. and Flah., but the larger and smaller trichomes appear to me to have a common origin."

EXPLANATION OF FIGURES ON PLATE I

All Figures magnified x 100 except figures 7 and 8

1. *Agmenellum thermale* (Kütz.) Dr. and Daily
2. *Anacystis cyanea* (Kutz.) Dr. and Daily (upper right) and *Gomphosphaeria wichurae* (Hilse) Dr. and Daily
3. *Calothrix parietina* Born. and Flah.
4. *Oscillatoria princeps* Vauch. (single large filament) and *Oscillatoria tenuis* Ag.
5. *Audouinella leibleinii* (Israels.) C. M. Palmer, N. Comb.
6. Radiating surface hairs of *Thorea andina* Moeb. and Lagerh.
7. Portion of thallus of *Thorea andina* Moeb. and Lagerh. (x 20)
8. Young branch of thallus of *Thorea andina* Moeb. and Lagerh. (x 40)


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Anacystis cyanea (*Kütz.*) *Dr. and Daily. Figure 2.*—Stonelick Lake, Clermont County, Ohio. Collected by C. M. Palmer and T. E. Maloney, October 19, 1951. Mixed with *Gomphosphaeria wichurae* and others which formed an extensive "bloom" up to 2 inches thick on the surface of the lake.

Anacystis montana (*Lightf.*) *Dr and Daily.*—Fairmount Sewage Treatment Plant, Dayton, Montgomery County, Ohio. Collected by A. Hirsch and Wm. Bridge Cooke, November 24, 1955. Identification by F. Drouet. Found growing among other algae, on those filters with intermittent flow of sewage, which shut off every night. Not found on filters with continuous flow.

Calothrix parietina *Born. and Flah. Figure 3.*—Aquarium in laboratory, Cincinnati, Hamilton County, Ohio. Isolated by C. M. Palmer from mixed growth as unialgal culture from which herbarium mounts were prepared, July 10, 1950. Identification by F. Drouet.

Fremyella diplosiphon (*Born. and Flah.*) *Dr.*—Aquarium in laboratory, Cincinnati, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which the herbarium mounts were prepared, July 24, 1950. Identification by F. Drouet.

Gomphosphaeria wichurae (*Hilse*) *Dr. and Daily. Figure 2.*—Stonelick Lake, Clermont County, Ohio. Collected by C. M. Palmer and T. E. Maloney, October 19, 1951. Identification by F. Drouet. Forming an extensive, dense blue-green "bloom" up to two inches thick on the lake. Producing a strong grassy odor. Mixed with smaller amounts of *Anacystis*, *Aphanizomenon*, *Anabaena*, *Trachelomonas*, and *Navicula*.

Hapalosiphon fontinalis (*Ag.*) *Born.*—Devou Lake, Covington, Kenton County, Kentucky. Collected by C. M. Palmer, October 31, 1955. Identification confirmed by F. Drouet. Found as blue-green cushionlike patches attached to bottom of glass in bottle of water which had been collected from Devou Lake on July 12, 1955, by R. Bordner, and had remained indoors since then.

Oscillatoria curviceps *Ag.*—Big Sandy River, Catlettsburg, Boyd County, Kentucky. Collected by F. Middleton, August 19, 1955, and by C. M. Palmer, September 25, 1955. Identification by F. Drouet. Forming a bubbly green surface "bloom" in pool just above dam.

Oscillatoria princeps *Vauch. Figure 4.*—Setter's pond, Cincinnati, Hamilton County, Ohio. Collected by H. Braus, August 13, 1950. Identification confirmed by F. Drouet. Material is giant size, the filaments when fresh, measuring up to 90 μ in diameter. These large filaments of *O. princeps* have been characterized as forma *maxima* (Kütz.) Rab. (Prescott, 1942).

Oscillatoria tenuis *Ag. Figure 4.*—Lytle Creek at Ogden, Clinton County, Ohio. Collected by C. M. Palmer, August 10, 1950. Identification by F. Drouet. Forming large, fragile, blue-green floating mats in quiet water areas at side of stream.

Phormidium uncinatum (*Ag.*) *Gom.*—Fairmount Sewage Treatment Plant, Dayton, Montgomery County, Ohio. Collected by A. Hirsch and Wm. Bridge Cooke, December 12, 1955. Identification by F. Drouet. Became abundant on trickling filters in May and found growing there through following winter. Forming dense brown or blackish-green pad on the rocks, often overgrowing other algae.

Plectonema nostocorum *Born.*—Meadville, Crawford County, Pennsylvania. Collected by W. M. Ingram, August 10, 1955. Identification by F. Drouet. Found on side of unused secondary settling tank of activated sludge sewage treatment installation, forming an extensive, velvety mat, about 1 cm thick. Exposed portion black-blue-green, portion below surface much lighter in color.

Symploca erecta *Pevalec.*—Aquarium in laboratory, Cincinnati, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which herbarium mounts were prepared July 25, 1950. Considered by F. Drouet to be *Plectonema nostocorum*. It is reported here as *Symploca erecta* because the growth has persistently developed the erect tufts which serve to characterize and to distinguish this genus.

Audouinella leibleinii (*Israels.*) *C. M. Palmer, N. Comb. Figure 5.*—Syn.: *Chantransia leibleinii* Kutz., Phyc. germ. p. 229, 1945; *Pseudochantransia chalybaea* var. *leibleinii* (Kutz.) Rab., Krypt.-Fl. 2: 115, 1847; *Pseudochantransia leibleinii* (Kutz.) Israels., Symbol. Bot. Upsal. 6 (No. 1): 58, 1942.

Scioto River, Ross County, Ohio. Collected by C. Henderson and C. M. Tarzwell, September 28, 1953, and in Scioto River, Pike County, September 24, 1953. Found in riffles.

Some authorities list this growth as the juvenile stage of a *Batrachospermum*. The material from the Scioto River is considered to be in its mature condition and not the juvenile stage of another alga. For this reason it is placed in the genus *Audouinella* which according to Papenfuss (1945) should replace the name *Chantransia* for the fresh-water forms.

Thorea andina *Moeb. and Lagerh. Figures 6, 7, 8.*—Scioto River, Piketon, Pike County, Ohio. Collected by A. Hirsch and C. M. Palmer, October 22, 1953.

Found in riffle. One species (*T. ramosissima*) of this rare genus was previously reported in Ohio from Cincinnati (Kellerman and Werner, 1893) and from Sandusky Bay (Riddle, 1903). Only two pieces of the thallus were found in present collection. Larger piece is 13 cm long with about 50 branches, 1 to 10 mm long; smaller piece is 6 cm long with numerous branches especially near base. No main axis evident in either piece. Much of thallus is approximately 1 mm in diameter, including radiating hairs; central strand of longitudinal filaments alone is approximately 0.5 mm in diameter. Originally, color black to naked eye, with a purplish marginal tinge; appearing brown under 6 x magnification, with light purple hairs covering surface. Color after drying and storing, tan to olive green, in both dry and wet condition.

Ankistrodesmus falcatus (*Corda*) *Ralfs.*—Fish hatchery pond at Newtown, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which herbarium mounts were prepared, August 28, 1950.

Ankistrodesmus falcatus *var.* acicularis (*A.Br.*) *G. S. West.*—Fish hatchery pond at Newtown, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which herbarium mounts were prepared, July 27, 1950.

Chlamydomonas communis *Snow.*—Fish hatchery pond at Newtown, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which herbarium mounts were prepared, July 27, 1950.

Chlamydomonas paradoxa *Pasch.*—Pond on Losantiville Avenue, Cincinnati, Hamilton County, Ohio. Collected by H. Braus, August 14, 1950. Isolated by C. M. Palmer as unialgal culture, from which herbarium mounts were prepared.

Chlorotylium mammiforme (*Babbis*) Kütz.—Small stream west of Devou Park, Covington, Kenton County, Ky. Collected by C. M. Palmer and T. E. Maloney, May 14, 1952. Forming a bright green growth on rocks. This material does not show the zonate growth characteristic of *Chlorotylium cataractarum* Kütz., a species previously reported from Kentucky (Collins, 1909).

Oocystis lacustris *Chodat. Figure 18.*—Lytle Creek at Ogden, Clinton County, Ohio. Collected by A. Gaufin, August 1, 1950. Isolated by C. M. Palmer as unialgal culture from which the herbarium mounts were prepared. Found 4.8 stream miles below the entrance of organic pollution from the Wilmington Sewage Treatment Plant. Clean-water zone during the summer and recovery zone during the winter.

Oocystis marssonii *Lemmerm.*—Fish hatchery pond at Newtown, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which herbarium mounts were prepared August 28, 1950.

Scenedesmus obliquus (*Turpin*) *Kütz.*—Fish hatchery pond at Newtown, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which herbarium mounts were prepared July 27, 1950.

Stigeoclonium nanum *Kütz.*—Lytle Creek, Clinton County, Ohio. Collected by G. H. Paine, March 22, 1951. Identification by G. W. Prescott. Found attached to igneous rocks in riffle. Growing in association with *Ulothrix tenuissima*, 2 stream miles below entrance of organic pollution from the Wilmington Sewage Treatment Plant.

Fairmount Sewage Treatment Plant, Dayton, Montgomery County, Ohio. Collected by A. Hirsch and Wm. Bridge Cooke, November 21, 1955. Identification by G. W. Prescott. On trickling filters, growing in association with other algae, including *Ulothrix tenuissima*.

Fish hatchery pond at Newtown, Hamilton County, Ohio. Collected by C. M. Palmer, June 28, 1951. Identification by G. W. Prescott.

Lake at Burnet Woods, Cincinnati, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture October 3, 1950.

Tetraspora gelatinosa (*Vauch.*) *Desvaux. Figure 17.*—Lytle Creek at Ogden, Clinton County, Ohio. Collected by A. Gaufin and C. Howard, July 31, 1950. Growing on rocks in shallow riffle. (See *Oocystis lacustris* for note on habitat). An earlier collection from the

same location on July 19, 1950, represents younger material in a *Schizochlamys* stage, with dense, brownish caps outside of the protoplasts.

Ulothrix tenuissima *Kütz.*—Lytle Creek, Clinton County, Ohio. Collected by G. H. Paine, March 22, 1951. Identification by G. W. Prescott. Found attached to igneous rocks in riffle, growing in association with *Stigeoclonium nanum*. (See *S. nanum* for note on habitat).

Dayton Sewage Treatment Plant, Dayton, Montgomery County, Ohio. Collected by A. Hirsch and Wm. Bridge Cooke, November 21, 1955. Identification by G. W. Prescott. Found on rocks of trickling filter, growing in association with other algae, including *Stigeoclonium nanum*.

Euglena mutabilis *Schmitz and* Lepocinclis ovum (*Ehr.*) *Lemmerm.*—Snow Creek, Murray City, Hocking County, Ohio. Collected by Wm. Bridge Cooke, April 10, 1954. These two genera both abundant in creek with pH of about 4.0. Growing mixed with *Eunotia*, *Achnanthes*, and *Navicula*.

Centritractus belonophorus *Lemmerm.*—Scioto River, Pike County, Ohio. Collected by C. Henderson and C. M. Tarzwell, September 30, 1953. Also found by A. Hirsch in Scioto River in Franklin County and in the following tributaries of the Scioto during July 1954: Big Walnut Creek, Franklin County; Walnut Creek, Pickaway County; and Big Darby Creek, Pickaway County. Occurred infrequently in the plankton.

Achnanthes linearis (*W. Smith*) *Cleve*. *Figure 9.*—Fish hatchery pond, Newtown, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture, from which herbarium mounts were prepared July 27, 1950.

Biddulphia laevis *Ehr*. *Figures 13 and 14.*—Scioto River, Ross County, Ohio. Collected by C. Henderson and C. M. Tarzwell, September 23, 1953. Identification confirmed by P. S. Conger. Found a number of times in Scioto River in Ross and Pike Counties during fall of 1953 and summer of 1954, growing entangled among *Hydrodictyon*, *Cladophora* and other filamentous algae. Also infrequently in the plankton. Smith (1950) reports *B. laevis* as being found in Nebraska. P. S. Conger (written communication March 12, 1956) states that this species often occurs in great numbers, sometimes growing attached to rocks in rapid water.

Cymbella microcephala *Grun* *Figure 10.*—Cowan Lake, Clinton County, Ohio. Collected by C. M. Palmer, August 29, 1950. Growing mixed with *Bulbochaete*, *Agmenellum*, *Staurastrum*, *Synedra*, *Cyclotella*, *Crucigenia*, and *Mougeotia*, on concrete wall, just below water surface.

Gomphonema parvulum (*Kütz.*) *Grun*. *Figure 16.*—Glass aquarium kept at 20° C. under artificial light in laboratory, Cincinnati, Hamilton County, Ohio. Isolated by C. M. Palmer as unialgal culture from which herbarium mounts were prepared July 24, 1950.

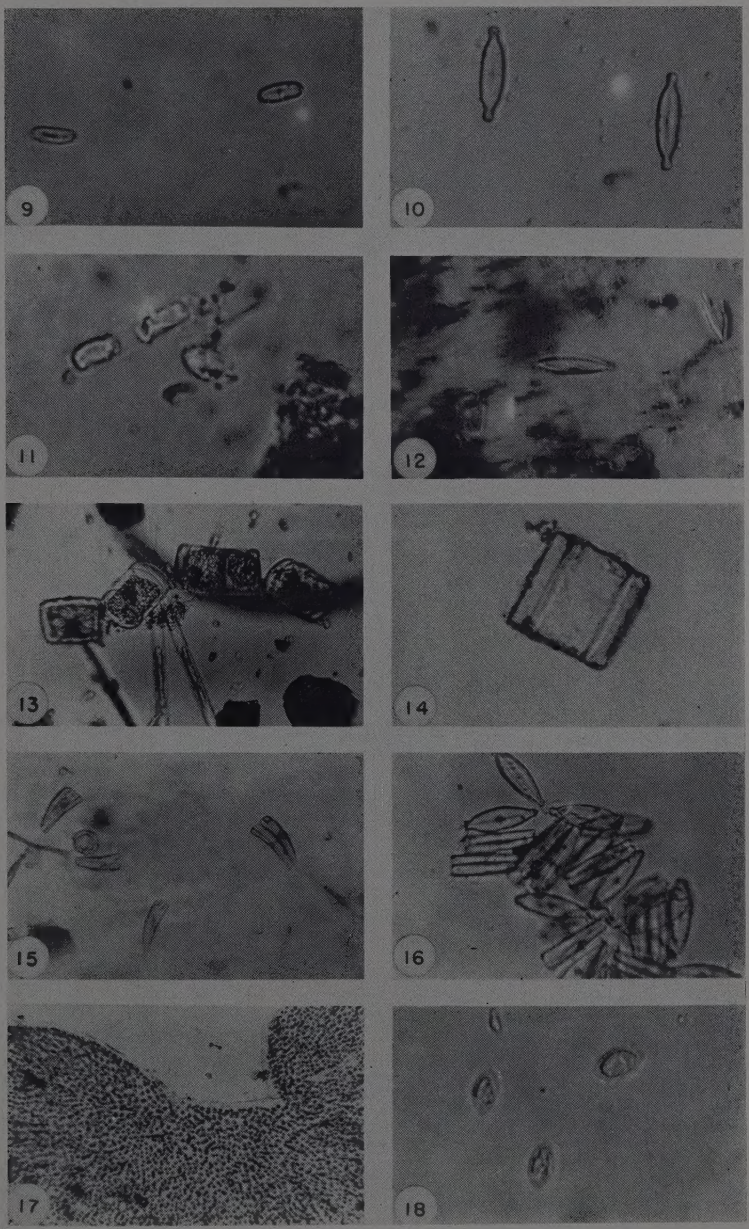
Melosira crenulata *Kütz. var.* tenuis (*Kütz.*) *Grun*. *Figure 11.*—Scioto River, Pike County, Ohio. Collected by A. Hirsch, May 19, 1954. Identification by P. S. Conger who describes this form (written communication November 4, 1955) as an ". . . exceptionally delicate variety. There is much question and uncertainty about this even in the books. Some make it *M. italica* O. Müll. var. *crenulata*, but that is merely synonymous and does not affect the identification." This form is illustrated in A. Schmidt Atlas d. Diatomaceenkunde, pl. 1, Figs. 53 or 56.

Collected by A. Hirsch a number of times in Scioto River in Franklin, Pickaway, Ross, and Pike Counties, Ohio, from February through September 1954. Also collected in the following tributaries of the Scioto during July 1954: Mill Creek, Delaware County; Olentangy River.

EXPLANATION OF FIGURES ON PLATE II

All figures magnified x 500 except figures 13, 14, 17, and 18

9. *Achnanthes linearis* (W. Smith) Cleve
10. *Cymbella microcephala* Grun.
11. *Melosira crenulata* Kütz. var. *tenuis* (Kütz.) Grun.
12. *Nitzschia palea* (Kütz.) W. Smith
13. Colony of *Biddulphia laevis* Ehr. (x 100)
14. Single cell, girdle view, of *Biddulphia laevis* Ehr. (x 200)
15. *Rhoicosphenia curvata* (Kütz.) Grun.
16. *Gomphonema parvulum* (Kütz.) Grun.
17. *Tetraspora gelatinosa* (Vauch.) Desvaux (x 100)
18. *Oocystis lacustris* Chodat (x 100)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Franklin County; Big Walnut Creek, Franklin County; Big Darby Creek, Pickaway County; Deer Creek, Ross County; Paint Creek, Ross County. A minute, very delicate diatom occurring in one, two, and occasionally three-celled chains. Extremely abundant in the river in May 1954, when its numbers were over 160,000 organisms per ml in the plankton, coloring the water brown. Also common as a bottom alga at that time, forming a brown slime on sheltered sand bars, where it was growing in association with *Nitzschia*, *Cyclotella*, and other diatoms.

Nitzschia palea (*Kütz.*) *W. Smith. Figure 12.*—Fairmount Sewage Treatment Plant, Dayton, Montgomery County, Ohio. Collected by A. Hirsch and Wm. Bridge Cooke, October 17, 1955. Identification by P. S. Conger (written communication November 4, 1955) who describes this form as ". . . probably a *Nitzschia palea* (Kütz.) W. Sm. or *N. Kützingiana* Hilse which is very close, perhaps a variety of the former." Found on trickling filters throughout the year, forming brownish slime or scattered among other algae.

Lytle Creek, at Ogden, Clinton County, Ohio. Collected by C. M. Palmer, August 7, 1950, and T. E. Maloney, February 28, 1952. Isolated by C. M. Palmer as unialgal culture (See *Oocystis lacustris* for note on habitat).

Rhoicosphenia curvata (*Kütz.*) *Grun. Figure 15.*—Seven Mile Creek north of Hamilton, Butler County, Ohio. Collected by C. M. Palmer, May 28, 1953. Identification confirmed by P. S. Conger.

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